

**BENCH-SCALE TREATABILITY TESTING
REPORT**

FINAL

**FORMOSA PLASTICS CORPORATION, TEXAS
POINT COMFORT, TEXAS**

Prepared for:

FORMOSA PLASTICS CORPORATION
Point Comfort, Texas

March 21, 2013

Prepared by:

PASTOR, BEHLING & WHEELER, LLC
620 E. Airline
Victoria, Texas 77901
(361) 573-6442
Fax: (361) 573-6449

PBW Project No. 3251

TABLE OF CONTENTS

	<u>Page</u>
LIST OF TABLES	ii
LIST OF FIGURES	ii
LIST OF APPENDICES	ii
LIST OF ACRONYMS	iii
1.0 INTRODUCTION	1
2.0 BACKGROUND	3
3.0 TREATABILITY STUDY DESIGN	6
3.1 Introduction	6
3.2 In-Situ Chemical Oxidation (ISCO)	6
3.3 Enhanced Bioremediation	8
3.4 Mass Removal Pilot Testing	9
4.0 STUDY RESULTS	10
4.1 ISCO	10
4.2 Enhanced Bioremediation	13
4.3 Mass Removal	14
5.0 CONCLUSIONS	16
5.1 ISCO	16
5.2 Enhanced Bioremediation	17
5.3 Mass Removal	17
6.0 REFERENCES	18

LIST OF TABLES

Table 1	ISCO Tests Data Summary – EDC and VOCs
Table 2	ISCO Tests Data Summary – General Parameters
Table 3	Enhanced Bioremediation Test Data Summary – EDC and VOCs

LIST OF FIGURES

Figure 1	Area Location Map
Figure 2	Site Location Map

LIST OF APPENDICES

Appendix A	Boring Log for Well TS-1
Appendix B	ISOTEC Report – ISCO
Appendix C	FMC Report – Enhanced Bioremediation
Appendix D	Gainco Report – Multi-Phase Extraction

LIST OF ACRONYMS

AOC	Area of Concern
ASP	Activated Sodium Persulfate
CAO	Corrective Action Objective
COPC	Chemical of Potential Concern
CSM	Conceptual Site Model
DNAPL	Dense Non-Aqueous Phase Liquid
DPE	Dual-Phase Extraction
EDC	1,2-Dichloroethane (or Ethylene Dichloride)
EPA	U.S. Environmental Protection Agency
FMC	FMC Environmental Solutions
FPC-TX	Formosa Plastics Corporation, Texas
GPM	Gallons Per Minute
ISCO	In-situ Chemical Oxidation
ISOTEC	In-Situ Oxidative Technologies, Inc.
mg/L	Milligrams Per Liter
MPE	Multi-Phase Extraction
ORP	Oxidation-Reduction Potential
PBW	Pastor, Behling & Wheeler, LLC
PCL	Protective Concentration Level
RFI	RCRA Facility Investigation
RMP	Risk Management Plan
ROI	Radius of Influence
SWMU	Solid Waste Management Unit
SVE	Soil Vapor Extraction
TDS	Total Dissolved Solids
TOC	Total Organic Carbon
TRRP	Texas Risk Reduction Program
VCM	Vinyl Chloride Monomer Process Area
VOCs	Volatile Organic Compounds
WWTP	Former Waste Water Treatment Plant
ZVI	Zero-Valent Iron

1.0 INTRODUCTION

In accordance with the U.S. Environmental Protection Agency (EPA) Administrative Order on Consent with Corrective Action Plan (CAP) dated February 27, 1991 (EPA Docket No. VI-001(h)-90-H; EPA I.D. No. TXT490011293), as amended, Formosa Plastics Corporation, Texas (FPC-TX) has undertaken measures to characterize and remediate soil and groundwater affected by volatile organic compounds (VOCs) at the Point Comfort facility. The FPC-TX facility is located in Calhoun County along State Highway 35 and Farm to Market Road (FM) 1593, adjacent to Lavaca Bay (Figure 1). The EPA's 1991 Order addresses a facility of approximately 256 acres.

The overall objective for groundwater cleanup is described in the Final Remedy Decision document of March 11, 2010, which includes specific Corrective Action Objectives (CAOs) for the final remedy to attain. The first CAO describes the groundwater plume containment goal:

Corrective Action Objective 1: The groundwater cleanup objective is to contain the plume, rather than return the groundwater to its maximum beneficial use throughout the plume. The groundwater point of compliance (POC) for FPC will be at the Facility boundary (including the former Brookings property), where concentrations of chemicals of concern must be less than or equal to the maximum contaminant limits (MCLs) for drinking water. (In the event an MCL is not established for a chemical of concern, a risk-based action level will be developed.)

As documented in the Final Risk Management Plan (RMP) (Tetra Tech, 2010), remaining Solid Waste Management Units (SWMUs) and associated potentially impacted soil and groundwater have been segregated into two distinct Areas of Concern (AOC) at the FPC-TX facility: AOC 1 – the former Waste Water Treatment Plant (WWTP) area located in the eastern portion of the site; and AOC 2 – the Vinyl Chloride Monomer (VCM) Process area located in the central portion of the facility.

In July 2012, FPC-TX submitted a work plan (PBW, 2012a) for conducting a bench-scale treatability study of soil and groundwater from the VCM and former WWTP areas. The work plan was approved by EPA in August 2012. The work plan proposed the evaluation of technologies to support CAO 2 of the Final Remedy Decision document:

Corrective Action Objective 2:

To support the final groundwater cleanup objective, FPC must remove or treat source material in soils and/or groundwater to the extent practicable. Using the Texas Risk Reduction Program (TRRP), soils with concentrations of COCs in excess of the soil saturation limit (C_{sat}) must be addressed, and groundwater with concentrations of COCs in excess of 1% solubility must be addressed through removal or treatment.

Three technologies were evaluated for viability in addressing source material:

- 1) In-situ chemical oxidation (ISCO) - treatment;
- 2) In-situ bioremediation - treatment;
- 3) Dual-phase extraction and removal - removal.

This report provides the results and conclusions of the treatability study performed per the approved work plan.

2.0 BACKGROUND

Soil and groundwater affected by volatile organic compounds (VOCs) are present at Formosa's Point Comfort facility. A comprehensive summary of existing environmental data was provided in the Areas of Concern Characterization Work Plan (Tetra Tech, 2012) and is not reproduced here. The Final Risk Management Plan (RMP) (Tetra Tech, 2010) also includes a detailed discussion of the nature and extent of potential soil and groundwater impacts and a conceptual site model (CSM). Both of the summaries mentioned above describe the results of the RCRA Facility Investigation (RFI) (C-K Associates, Inc., 1995). Further investigation of site soil and groundwater in the VCM and former WWTP areas was performed recently per the AOC Characterization Work Plan (Tetra Tech, 2012), as documented in the AOC Characterization Report (PBW, 2012b).

The main constituent of potential concern (COPC) identified in site soil and groundwater is 1,2-Dichloroethane (EDC). Other chlorinated hydrocarbons are also present in soil and groundwater samples at lower concentrations (e.g., chloroform, 1,1,2-trichloroethane, cis-1,2-dichloroethane, trans-1,2-dichloroethane, trichloroethene, vinyl chloride). There are two main areas at the site with COPCs at elevated concentrations: the former Waste Water Treatment Plant (WWTP) area in the eastern portion of the site and the VCM Process area in the central portion of the site. These areas are shown on Figure 2 as Areas of Concern (AOC) 1 and 2, respectively.

In the RMP, the Texas Risk Reduction Program (TRRP) protective concentration levels (PCLs) were used as a screening tool and compared to existing soil data. The $^{GW}Soil_{Ing}$ PCL (representing the soil-to-groundwater leaching and potential groundwater ingestion pathway) and the $^{Tot}Soil_{Comb}$ PCL (representing the inhalation, ingestion and dermal contact soil pathways) were identified as the most appropriate screening values. The $^{Tot}Soil_{Comb}$ PCL is generally several orders-of-magnitude higher than the $^{GW}Soil_{Ing}$ PCL for the COPCs at the site. As discussed in the RMP, contaminant concentrations in excess of the $^{Tot}Soil_{Comb}$ PCL were identified in soil samples collected at six SWMUs. Therefore, these areas represent the primary impacted soil areas at the site:

- SWMU #1 – Storm Water Basin;
- SWMU #21/22/23 – Inactive units adjacent to the active incineration area;
- SWMU #3 – Surge Basin; and
- SWMU #4 – Emergency Basin.

Evaluation of the existing soil data for the site also included an analysis of whether the soil samples collected during the RFI were from unsaturated soil or saturated soil. The saturation of the soil is an important factor in the consideration of remedial alternatives for soil since saturated soil is best

remediated via groundwater remediation technologies. The analysis of the soil data indicated that the soil samples from the interior of the Surge Basin and Emergency Basin are representative of unsaturated soil conditions. Coupled with the relatively high concentrations of EDC in the samples from these basins, these locations were considered ideal for collection of soil samples for treatability testing.

In the RMP, groundwater concentration data were evaluated for both elevated concentrations and trends. In the context of this work plan, the trend evaluation is less important than the elevated concentrations, since the treatability tests will be performed on groundwater that currently exhibits elevated COPC concentrations. In the RMP, wells where EDC concentrations in groundwater samples exceed or have exceeded one percent (1%) of the aqueous solubility for EDC (87 mg/L), thus defining the potential source areas, are as follows:

AOC 1:

- P-56 – Zone A, WWTP
- P-57 – Zone A, WWTP
- RS-6 – Zone A, WWTP

AOC 2:

- P-3 – Zone A, VCM
- P-36 – Zone A, VCM
- RS-3 – Zone A, VCM
- RS-1 – Zone A/B, VCM

- P-12 – Zone B, VCM
- RD-3 – Zone B, VCM

- D-11 – Zone C, VCM
- D-41 – Zone C, VCM
- RD-1 – Zone C, VCM
- D-2 – Zone C, VCM

Although EDC concentrations, and occasionally chloroform concentrations exceed 1% of the aqueous solubility limit in some samples, dense non-aqueous phase liquid (DNAPL) has not been observed in monitoring wells at the site. This may potentially be due to the age of the release, and that the contaminants may be sorbed-phase sources that can serve as long-term sources of contamination.

Based on the available information summarized above, the Surge Basin and Emergency Basin in AOC 1 appear to be the best locations for treatability studies since these areas have high COPC concentrations and both basins are in the inactive portion of the facility and easily accessible. It can be assumed, because of the known stratigraphy, that any treatment or removal technology that is successful for Zone

March 21, 2013

A, would be successful for Zones B and C, as each transport zone (A, B, and C) are made up of silty sands and are relatively shallow in depth (depth to top of Zone C occurs about 70 – 80 feet bgs).

3.0 TREATABILITY STUDY DESIGN

3.1 Introduction

Based on the specific characteristics of the site (e.g., groundwater quality, concentrations of COPCs in soil and groundwater, subsurface conditions, logistical issues, etc.), three remediation technologies were implemented for treatability testing: 1) in-situ chemical oxidation (ISCO), 2) enhanced bioremediation, and 3) multi-phase extraction (MPE). These three technologies have the potential to help meet the CAOs and remediation goals for the site.

Depending on the technology, treatability testing can be performed in the laboratory (i.e., bench-scale testing) or in the field (pilot-scale testing). Typically, bench-scale testing is performed first (if feasible). If the bench-scale test results are positive and indicate that a particular technology may be effective at a given site, pilot-scale testing may be warranted. Bench-scale testing was chosen to initially evaluate the ISCO and enhanced bioremediation technologies. Multi-phase extraction is not typically performed at the bench-scale level and should be performed as a pilot-scale test at the site where the COCs are present in environmental media. Therefore, the multi-phase extraction test was performed as a pilot-scale test at the FPC-TX site. Multi-phase extraction is also referred to as dual-phase extraction (DPE) in this report.

The following sections describe the treatability testing program designed to evaluate the selected remediation technologies.

3.2 In-Situ Chemical Oxidation (ISCO)

In-situ chemical oxidation (ISCO) uses strong oxidants to reduce the concentrations of targeted contaminants to acceptable levels. ISCO is accomplished by injecting or otherwise introducing the oxidants directly into the contaminated medium (soil or groundwater) to destroy chemical contaminants in place. Chlorinated ethanes such as EDC are amenable to destruction by chemical oxidation and ISCO is potentially an effective treatment method for soil and groundwater impacted by EDC at the site.

This technology is mainly applicable for saturated media including soil and groundwater; however, in some cases ISCO can be configured to address unsaturated soil by artificially saturating the vadose zone to permit treatment.

Based on the review of potential available oxidant chemistries and the properties of site COPCs, two oxidants (reagents) were selected for bench-scale testing: (1) modified Fenton's reagent (MFR), and (2) activated sodium persulfate (ASP). The sodium persulfate was evaluated using two activation methods, (1) heat (ASP-HEAT) and (2) alkali (ASP-ALK). A bench-scale test was performed for each oxidant.

Specific goals of the bench-scale study were to:

- Determine destruction of COPCs for each oxidant;
- Determine whether removal by modified Fenton's reagent is due to destruction or volatilization;
- Evaluate the effect of treatment on secondary water quality parameters;
- Measure soil oxidant demand for activated persulfate (each activator); and
- Estimate the longevity of modified Fenton's reagent in the presence of soil.

Groundwater and soil samples for the ISCO bench scale study were collected from the WWTP Surge Basin/Emergency Basin area. An evaluation of historic groundwater data indicated that samples from wells P-56 and P-57 (Figure 4) typically exhibit elevated concentrations of EDC and were considered suitable for the treatability testing¹. Soil samples were collected using direct-push technology from borings immediately adjacent to wells P-56 and P-57. The soil samples were collected from the Zone A sand interval from approximately 11.9 to 13.6 feet below ground level (see boring log for well TS-1 in Appendix A). Four separate borings were necessary to collect the volume of material needed for the ISCO bench-scale treatability study (as well the material needed for the bench-scale bioremediation study, see Section 4.3). The borings were drilled as near as feasible to one another. All borings were properly plugged and abandoned immediately after the completion of sampling. The soil samples were collected using standard collection and decontamination techniques that minimized cross-contamination, were immediately placed on ice for preservation, and were shipped to ISOTEC using standard chain-of-custody procedures. Groundwater samples were collected from well P-56 using the same methods used during the quarterly groundwater monitoring events.

In-Situ Oxidative Technologies, Inc. (ISOTEC) of Lawrenceville, New Jersey performed the ISCO bench-scale studies on the site soil and groundwater, as described in their study proposal included in the work plan. ISOTEC's study report is included in Appendix B of this report. The results of the study are described in Section 4.1.

¹ The concentrations of EDC in the samples from P-56 and P-57 were 1,299.7 mg/L and 667.1 mg/L, respectively, in the first quarter 2012 sampling event.

3.3 Enhanced Bioremediation

Enhanced bioremediation is a general term used to describe a variety of remedial technologies whereby the natural microbes in the environment are supplemented with additional microbes (bioaugmentation), nutrients, oxygen (aerobic bioremediation) and/or reducing agents (anaerobic bioremediation) to enhance the natural destruction of contaminants. Anaerobic bioremediation (also called reductive dechlorination or bio-chemical reduction) is considered a potential remedial technology for the FPC-TX site since chlorinated hydrocarbons such as EDC are amenable to reductive dechlorination and also for the following reasons:

- 1) The presence of high ethene concentrations from samples of groundwater from wells P-56 and P-57 may be indicative of the presence of anaerobic microorganisms that have adapted to site conditions and are potentially capable of degrading EDC;
- 2) The site groundwater exhibits overall reducing conditions (negative ORP values) and near neutral pH which indicates that conditions may be suitable for reductive dechlorination.

As for ISCO, this technology is mainly applicable for saturated media including soil and groundwater; however, in some cases bioremediation can be configured to address unsaturated soil by artificially saturating the vadose zone to permit treatment.

To evaluate the potential for reductive dechlorination to serve as a remedial technology at the site, a bench-scale treatability study was developed that used FMC Environmental Solutions (FMC) EHC[®] technology. The EHC technology uses a reagent that includes a controlled-release, integrated carbon (as a nutrient source) and zero-valent iron (ZVI) as a reducing agent to stimulate the reductive dechlorination of chlorinated solvents such as EDC.

As for the ISCO bench-scale study, groundwater and soil samples for the bioremediation bench scale study were collected from the WWTP Surge Basin/Emergency Basin area. The samples were collected at the same time as the samples for the ISCO treatability study.

FMC performed the enhanced bioremediation bench-scale studies on the site soil and groundwater, as described in their study proposal included in the work plan. FMC's study report is included in Appendix C of this report. The results of the study are described in Section 4.2.

3.4 Mass Removal Pilot Testing

Dual-phase extraction (DPE) (also called dual-phase recovery) is a proven contaminant mass removal technology for highly-contaminated source areas such as those identified at the site. Dual-phase extraction removes contaminants from both groundwater and vadose soils. Extraction from the vadose zone alone is called soil vapor extraction (SVE). Dual-phase extraction can be successful in a low permeable, low yield, heterogeneous formation such as that at the FPC-TX site and can achieve high contaminant mass removal rates. A dual-phase extraction system at the FPC-TX site could potentially remove a substantial portion of the contaminant mass in a relatively short period of time, thus reducing the overall remediation cost.

Gainco Inc. (Gainco) performed mass removal testing by removing soil vapor and groundwater from the subsurface by means of a vacuum. The test was performed at the well cluster including P-56, P-57 and RS-6. Well RS-6 was not used because the well casing contains a semi-permanent groundwater extraction pump and piping. Because the wells in this well cluster are relatively close together (less than 20 feet from one another), an additional temporary well was installed to evaluate the radius of influence of the vacuum. The well (TS-2) was installed using a geoprobe and was constructed to a depth of 15 feet below ground surface (bgs) with five feet of screen. For the DPE testing, Gainco provided mobile equipment powered by a self-contained power source and the appropriately sized high vacuum extraction equipment (e.g., liquid ring pump) capable of removing vapor and groundwater from the wells. The pilot test was conducted over two days, with the SVE and baseline groundwater extraction data collected the first day and high vacuum DPE data collected the second day.

Gainco's study report is included in Appendix C. The results of the study are described in Section 4.3.

4.0 STUDY RESULTS

4.1 ISCO

ISOTEC performed the ISCO study on site soil and groundwater samples as described in their report contained in Appendix B. Per the work plan (PBW, 2012a), ISOTEC used site soil and groundwater to set up a series of test reactors to perform the study. Site soil and groundwater samples were first composited (from the separate containers sent to ISOTEC by PBW). A portion of the composited soil and groundwater was submitted to a laboratory for initial chemical characterization (see Table 1 of this report and Table 1 of Appendix B). The remaining composited soil and groundwater were prepared into a slurry by mixing at a soil-to-water ratio of 2:1 by weight². A total of three tests were performed, one for each of the three reagents (MFR, heat-activated sodium persulfate (ASP-HEAT), and alkali-activated sodium persulfate (ASP-ALK)). All three tests were performed with an oxidant and an activating agent, as shown in the following table.

TEST	OXIDANT	ACTIVATING AGENT
Modified Fenton's Reagent (MFR)	Stabilized hydrogen peroxide (H ₂ O ₂)	ISOTEC Catalyst Series 4260 (circum-neutral pH organometallic complex (chelated iron))
Activated Sodium Persulfate – Alkali (ASP-ALK)	Sodium persulfate (Na ₂ S ₂ O ₈)	Sodium hydroxide (NaOH)
Activated Sodium Persulfate – Heat (ASP-HEAT)	Sodium persulfate (Na ₂ S ₂ O ₈)	Heat (60°C)

For each test, a total of four reactors were set up, with one reactor serving as the “control” and the remaining three serving as “treatment” reactors. The reactors consisted of 250 mL glass jars with screw-top caps fitted with Teflon septa to facilitate reagent injection. Each reactor consisted of the same quantity of soil/groundwater slurry at the start of the tests. Reagents were evaluated at three doses, as shown in the following table.

OXIDANT DOSE	MFR TEST	ASP-ALK TEST	ASP-HEAT TEST
Low Dose	6.6 g/Kg	6 g/Kg	6 g/Kg
Medium Dose	33.3 g/Kg	30 g/Kg	30 g/Kg
High Dose	66 g/Kg	60 g/Kg	60 g/Kg
Test Duration	3 days	10 days	1 day

² A 2:1 mixture by weight consisted of 100 grams of soil and 50 ml of water. Water has a density of 1 g/mL.

The duration of the tests ranged from 1 day to 10 days, as shown in the table. At the end of the test, the reactors were "quenched" to terminate the reactions to minimize subsequent VOC loss. The contents of each reactor was then separated into solid and aqueous phases and submitted for the chemical analyses described in the work plan. A summary of the post-test chemical analyses is provided on Table 1 of this report.

The results of post-test chemical analyses of the soil and groundwater indicate that all three reagents were effective at treating EDC and other VOCs detected at the site (Table 1). The maximum EDC and total VOC reduction was greater than 99% in both the solid and aqueous phases. Destruction of EDC was also greater at the higher reagent doses, as would be expected. In general, the medium reagent dose for all three reagents resulted in a minimum 86% reduction in EDC/VOC concentrations. The high reagent dose for all three reagents resulted in a minimum 98% reduction in EDC/VOC concentrations. Among the three reagents, MFR resulted in the greatest EDC/VOC concentration reductions at the low dose. ASP-ALK resulted in the greatest EDC/VOC concentration reductions at the high dose (99.9%).

ISOTEC noted that characteristics of the site also influence the ability of the reagents to reduce EDC/VOC concentrations in soil and groundwater. Iron and manganese concentrations in soil and groundwater are important catalysts in the MFR and persulfate reactions that result in EDC/VOC destruction. The total iron, ferrous iron and manganese concentrations in site groundwater are below the minimum concentrations necessary for proper activation of the reagents. Therefore, external catalyst would be required for field application of these reagents. Furthermore, although iron and manganese are found in site soil, they are mostly in the form of oxyhydroxides. The oxyhydroxides will promote some Fenton-like reactions, but they are generally unavailable to act as effective catalysts and can result in oxidant wastage (i.e., the oxidant is used in chemical reactions other than those responsible for EDC/VOC reduction). Finally, the background total organic carbon (TOC) concentrations in site soil and groundwater are expected to exert a moderate to high oxidant demand (oxidant scavenging). In other words, the TOC will compete with the contaminants for oxidant and result in lower VOC reductions than in a system with less available TOC.

The effects of the reagents on the general chemistry of the treated groundwater were also evaluated during the study (see Table 2 of this report), as follows:

- 1) pH – The pH of site groundwater is typically in the range of 6-7 standard pH units. The pH of the groundwater from well P-56 was 6.55 at the time of sample collection. The pH of the treated water remained in this general range for the MFR and ASP-HEAT tests. A slight rise in pH was observed in the MFR test; a slight decrease was observed in the ASP-HEAT test. The pH of the

- groundwater in the ASP-ALK test increased significantly due to addition of the highly-alkaline sodium hydroxide.
- 2) ORP – the ORP of site groundwater is variable, ranging from slightly positive to slightly negative. The ORP of the groundwater from well P-56 was measured at -125 at the time of sample collection. The ORP of the treated groundwater remained stable for the MFR test. The ORP of the treated groundwater decreased during the ASP-ALK test. The ORP increased slightly during the ASP-HEAT test. It is important to note that ORP is a sensitive parameter and is difficult to measure, which may explain the variability observed in the test results.
 - 3) TDS – the TDS of site groundwater is variable, ranging from less than 5,000 mg/L to greater than 10,000 mg/L. The TDS of the groundwater from well P-56 was 9,150 mg/L. The TDS of the treated groundwater increased slightly in the MFR test. The TDS of the treated groundwater increased significantly during the persulfate tests due to the addition of the sulfate present in the reagent.

As noted on page 13 of the ISOTEC report, a bench-scale study only evaluates the oxidation “chemistry” of the various oxidants as it relates to site contaminants and certain site characteristics. In other words, it evaluates whether the oxidants can treat the contaminants present at the site. In the current study performed by ISOTEC, the oxidants were successful in reducing EDC and other VOC concentrations using site soil and groundwater.

Bench-scale conditions are very different from in-situ conditions. For instance, although the 2:1 soil-to-groundwater mixture is an industry standard for bench-scale tests, it does not simulate natural conditions. Natural in-situ conditions typically have a soil-to-water ratio of approximately 5.8:1 (assuming 30% porosity). Furthermore, in-situ soil particles are compacted and inhibit the entry of the oxidants into the particle matrix.

In-situ conditions present a unique set of obstacles relative to bench-scale conditions and the implementation of ISCO remediation in the field is much more complex than in the laboratory. Remediation requires the appropriate combination of injection pressures, volumes and flow rates; reagent type and concentration; and injection spacing – all intended to achieve a uniform distribution of reagents in the subsurface. These parameters have to be linked with the site conditions such as grain size, site stratigraphy, depth to water, etc. For most sites, including the FPC-TX site, actual in-place oxidant loading and concentrations will likely be lower than those in the study to address site conditions such as the presence of interbedded low-permeability soils and a shallow water table.

Finally, ISOTEC observed that the reduction in EDC/VOC concentrations in both the solid and aqueous phases was very limited for both the low-dose persulfate applications, but this was not the case for the low-dose MFR application (see pages 13-14 of the ISOTEC report in Appendix B). Given the site characteristics noted in the previous paragraphs, field applications of ISCO will mimic the low-dose applications. Since contaminant mass reduction typically comes from a cumulative effect of multiple

low-dose applications (as opposed to one medium- or high-dose application), it does not appear that multiple low-dose applications of activated persulfate will lead to cumulative contaminant mass reduction. However, multiple low-dose applications of MFR should produce a cumulative contaminant mass reduction. Based on these conclusions, a field pilot study using MFR as the oxidant is recommended by ISOTEC.

4.2 Enhanced Bioremediation

FMC performed a bench-scale treatability study to evaluate the enhanced bioremediation technology as described in Section 3.2 and in their report in Appendix C. FMC used its EHC[®] technology which uses controlled-release, integrated carbon (as a nutrient source) and zero-valent iron (ZVI) as a reducing agent to stimulate the reductive dechlorination of chlorinated solvents such as EDC.

Site soil and groundwater samples were first composited (from the separate containers sent to FMC by PBW). A portion of the composited soil and groundwater was submitted to a laboratory for initial chemical characterization. The bench-scale test was set up as outlined in FMC's proposal contained in the work plan (PBW, 2012a) and in their study report included in Appendix C. One EHC treatment microcosm and two control microcosms (groundwater and ambient) were prepared. Sacrificial jars (glass jars with Teflon-lined lids) were set up for the control and treatment microcosms. Two sizes of jars were used (250 mL and 1 L) to allow for sampling of additional parameters during the final sampling event. The groundwater control microcosms were filled with the composited groundwater to zero headspace and capped. The ambient control microcosms contained the homogenized soil (75g for the 250 mL jar; 300 g for the 1 L jar) and were filled with site groundwater to zero headspace and capped. The EHC microcosms were filled with the homogenized site soil, 0.5% EHC reagent (1.5 g for the 250 mL jar; 5.7 g for the 1 L jar), and site groundwater to zero headspace and capped. The mass of EHC was added based on the total mass of soil and groundwater in the microcosms. All microcosms were inverted several times to mix.

Time zero samples were collected from the ambient control (soil plus water) microcosm on the first day of the test. Samples were collected from the water control, ambient control and EHC treatment microcosms at week 4 (Day 28) and week 8 (Day 56). Review of the results from the Day 56 sampling event (Table 3) indicated a low rate of VOC destruction³ by EHC alone, likely due to either 1) the high

³ The rate of VOC destruction in the EHC treatment microcosm was calculated by comparing the concentration from the EHC treatment microcosm sample for a particular sampling event to the ambient control microcosm sample also collected during that sampling event.

concentrations of EDC and other VOCs were toxic to the natural microbes present; or b) the appropriate microbes were not naturally present at the site. Based on these results, a decision was made to bioaugment the EHC treatment microcosm by adding a commercially-available mixed culture of SDC-9 (*Dehalococcoides*) and TCA-20 (*Dehalobacter*). Bioaugmentation was conducted on day 85 of the test. A sampling event was conducted in week 14 (Day 99), the results of which again indicated poor destruction of VOCs. Therefore, the low rate of destruction of VOCs is thought to be due to the high concentrations of EDC and VOCs in the soil and groundwater used for the tests, not the absence of the appropriate microbes at the site. The test was terminated after review of the Day 99 results and a final report prepared (Appendix C).

In summary, the EHC treatment with bioaugmentation did not result in significant reductions in EDC concentrations in the samples. At Day 99 of the test, the concentration of EDC in the EHC treatment microcosm was reduced by 33.6% compared to the ambient control microcosm. A similar reduction in total VOCs was observed (35.9%). Although the rate of EDC destruction was low, other VOCs showed better rates of destruction (e.g., chloroform), presumably as a result of reductive dechlorination.

4.3 Mass Removal

Gainco performed the mass removal study at well cluster P-56/P-57/RS-6, as described in their report contained in Appendix D. Per the work plan (PBW, 2012a), Gainco performed a three-phase test to determine whether SVE or high vacuum DPE technology is suitable for remediation of the site. The test apparatus consisted of a liquid ring pump connected to a 1-inch diameter PVC pipe (stinger) that was inserted into well P-57 (the "extraction well" in the context of this test). Stage 1 was performed by applying a vacuum in a step-wise fashion in well P-57 with the stinger approximately 9-10 feet above the water level and with the annular space between the stinger and well casing sealed. The duration of the test was 90 minutes and measurements of vacuum were taken from wells P-57, P-56, and temporary well TS-2 that was installed for the purposes of this study. Stage 2 of the study consisted of a short-term pump test performed with the stinger placed near the bottom of well P-57. Water-level measurements were taken from wells P-56 and TS-2 during the test to allow for estimation of aquifer properties. Stage 3 of the study evaluated DPE by applying a constant vacuum in well P-57 with the stinger below the water level and with the annular space between the stinger and the well casing sealed. Measurements of groundwater extraction rate, subsurface vacuum, volatile organic compound concentration (via a photoionization detector) were collected during the six-hour test.

The results of the study are included in the Gainco report contained in Appendix D, including tables, figures and graphs. The major conclusions of the study are:

- 1) The average mass of hydrocarbons removed was approximately ten times greater with high-vacuum DPE than with SVE alone (0.83 lb/hr for DPE versus 0.072 lb/hr for SVE). Although the low permeability of the soil at the site reduces overall effectiveness, the relatively high volatility of EDC and the other hydrocarbons present at the site make these contaminants viable candidates for remediation via DPE. SVE alone is not likely a suitable remedial technology for the site.
- 2) The hydrocarbon mass removal was low using SVE alone. Attempts to apply a high vacuum in well P-57 using SVE alone resulted in an increase in the water level above the well screen, precluding the removal of soil vapor using this method. These results are likely due to the relatively low permeability of the soils present at the site. As mentioned above, SVE alone is not likely a suitable remedial technology for the site.
- 3) The radius of influence (ROI) of the vacuum in the subsurface predicted by the tests was 7.5 feet for SVE and 11.5 feet for DPE.
- 4) The average groundwater recovery rate during the pump test (Stage 2) was 0.57 gallons per minute (gpm). The average groundwater recovery rate during the DPE test (Stage 3) was 0.49 gpm.
- 5) The hydraulic conductivity of the Zone A sand interval estimated by the pump test (Stage 2) was 1.34×10^{-2} cm/sec (38 ft/day). This estimate is approximately one order of magnitude greater than previous estimates of the hydraulic conductivity of the Zone A sand at this location and at other locations at the site.

Based on these conclusions, DPE remains a potentially viable remediation alternative for the site. Further evaluation of DPE should be conducted by performing a pilot-scale test of longer duration (e.g., three days).

5.0 CONCLUSIONS

5.1 ISCO

The results of post-test chemical analyses of the soil and groundwater indicate that all three ISCO reagents were effective at treating EDC and other VOCs detected at the site. The maximum EDC and total VOC reduction was greater than 99% in both the solid and aqueous phases. Destruction of EDC was also greater at the higher reagent doses, as would be expected.

Iron and manganese concentrations in soil and groundwater are important catalysts in the FMR and persulfate reactions that result in EDC/VOC destruction. The total iron, ferrous iron and manganese concentrations in site groundwater are below the minimum concentrations necessary for proper activation of the reagents. Therefore, external catalyst would be required for field application of these reagents. Also, the background total organic carbon (TOC) concentrations in site soil and groundwater are expected to exert a moderate to high oxidant demand (oxidant scavenging).

A limitation of the study is that a bench-scale study only evaluates the oxidation "chemistry" of the various oxidants as it relates to site contaminants and certain site characteristics. For the current study performed by ISOTEC, the oxidants were successful in reducing EDC and other VOC concentrations using site soil and groundwater. However, in-situ conditions present a unique set of obstacles relative to bench-scale conditions and the implementation of ISCO remediation in the field is much more complex than in the laboratory. Remediation requires the appropriate combination of injection pressures, volumes and flow rates; reagent type and concentration; and injection spacing – all intended to achieve a uniform distribution of reagents in the subsurface. These parameters have to be linked with the site conditions such as grain size, site stratigraphy, depth to water, etc. For most sites, including the FPC-TX site, actual in-place oxidant loading will likely be lower than in the study to address site conditions such as the presence of interbedded low-permeability soils and a shallow water table.

Finally, ISOTEC observed that the reduction in EDC/VOC concentrations in both the solid and aqueous phases was very limited for both the low-dose persulfate applications, but this was not the case for the low-dose MFR application. Given the site characteristics, field applications of ISCO will mimic the low-dose applications. Since contaminant mass reduction typically comes from a cumulative effect of multiple low-dose applications (as opposed to one medium- or high-dose application), it does not appear that multiple low-dose applications of activated persulfate will lead to cumulative contaminant mass reduction. However, multiple low-dose applications of MFR should produce a cumulative contaminant

mass reduction. Based on these conclusions, a field pilot study using MFR as the oxidant is recommended by ISOTEC.

5.2 Enhanced Bioremediation

The EHC treatment did not result in significant reductions in EDC concentrations in the bench test samples over a period of 99 days. The low rate of EDC destruction is likely due to the high concentrations of EDC and other VOCs present in the samples, which were toxic to the natural microbes present. Furthermore, bioaugmentation of the samples during the bench test with common cultures did not result in significant reductions in EDC concentrations.

5.3 Mass Removal

The three-stage mass removal pilot test evaluated SVE alone and DPE as potential remedial technologies for the site. The study results indicated that SVE alone is not viable at this site due to the relatively low permeability of the soils at the site. In the pilot test, the application of a high vacuum increased the groundwater level in the well, precluding the removal of vapor phase contamination from the vadose zone.

The average mass of hydrocarbons removed was approximately ten times greater with high-vacuum DPE than with SVE alone. Although the low permeability of the soil at the site reduces overall effectiveness, the relatively high volatility of EDC and the other hydrocarbons present at the site make these contaminants viable candidates for remediation via DPE. Further evaluation of DPE should be conducted by performing a pilot-scale test of longer duration (e.g., three days).

6.0 REFERENCES

- C-K, 1995. C-K Associates, Inc. Supplemental RCRA Facility Investigation. Prepared for Formosa Plastics Corporation, Texas. June. Revised May 1998.
- Pastor, Behling & Wheeler, LLC (PBW), 2012a. Bench-Scale Treatability Testing Work Plan. Prepared for Formosa Plastics Corporation, Texas. July.
- Pastor, Behling & Wheeler, LLC (PBW), 2012b. AOC Characterization Report. Prepared for Formosa Plastics Corporation, Texas. November.
- Tetra Tech, 2010. Final Risk Management Plan. Prepared for Formosa Plastics Corporation, Texas. April 30.
- Tetra Tech, 2012. Areas of Concern Characterization Work Plan. Prepared for Formosa Plastics Corporation, Texas. May 4.

TABLE 1. ISCO TESTS DATA SUMMARY – EDC AND VOCs

AQUEOUS PHASE (concentrations in ug/L)				
	EDC	TOTAL VOCs	EDC REDUCTION	VOC REDUCTION
INITIAL CONDITIONS	1,280,000	1,408,780	--	--
MODIFIED FENTON'S REAGENT TEST				
Control	470,000	519,980	--	--
Low Dose	185,000	208,760	60.64%	59.85%
Medium Dose	30,600	35,114	93.49%	93.25%
High Dose	8,190	10,676	98.26%	97.95%
ALKALI-ACTIVATED SODIUM PERSULFATE TEST				
Control	652,000	700,690	--	--
Low Dose	497,000	524,220	23.77%	25.19%
Medium Dose	86,100	92,888	86.79%	86.74%
High Dose	243	667.86	99.96%	99.90%
HEAT-ACTIVATED SODIUM PERSULFATE TEST				
Control	746,000	806,720	--	--
Low Dose	568,000	612,240	23.86%	24.11%
Medium Dose	2,750	38,372	99.63%	95.24%
High Dose	200	16,901	99.97%	97.90%
SOLID PHASE (concentrations in mg/Kg)				
	EDC	TOTAL VOCs	EDC REDUCTION	VOC REDUCTION
INITIAL CONDITIONS	44.9	47.4	--	--
MODIFIED FENTON'S REAGENT TEST				
Control	64.10	67.1	--	--
Low Dose	16.7	17.7	73.95%	73.66%
Medium Dose	0.011	0.01	99.98%	99.98%
High Dose	0.0063	0.01	99.99%	99.99%
ALKALI-ACTIVATED SODIUM PERSULFATE TEST				
Control	116	122.52	--	--
Low Dose	124	129.01	Increase	Increase
Medium Dose	12.8	13.63	88.97%	88.88%
High Dose	0.063	0.06	99.85%	99.95%
HEAT-ACTIVATED SODIUM PERSULFATE TEST				
Control	74	77.24	--	--
Low Dose	75	78.40	Increase	Increase
Medium Dose	0.487	2.17	99.34%	97.19%
High Dose	0.053	1.01	99.93%	98.69%

Notes:

- 1) See ISOTEC report (Appendix B) for complete data and discussion.

TABLE 2. ISCO TESTS DATA SUMMARY – GENERAL PARAMETERS

AQUEOUS PHASE (concentrations in ug/L)										
	pH (SU)	ORP (mV)	TDS (mg/L)	Fe2+ (ug/L)	Sulfate (SO ₄) (ug/L)	TOC (ug/L)	Total Iron (ug/L)	Manganese (ug/L)	Alkalinity (ug/L)	Nitrate (ug/L)
INITIAL COND.	6.55	-125	9,150	4,960	378,000	8,540	8,710	7,930	606,000	ND (<500)
MODIFIED FENTON'S REAGENT TEST										
Control	6.51	185	5,940	< 40	--	--	--	--	--	--
Low Dose	6.63	182	6,286	< 40	--	--	--	--	--	--
Medium Dose	6.90	189	8,220	< 40	--	--	--	--	--	--
High Dose	7.15	203	11,070	< 40	--	--	--	--	--	--
ALKALI-ACTIVATED SODIUM PERSULFATE TEST										
Control	6.6	46	10,880	--	--	--	--	--	--	--
Low Dose	11.36	-159	18,340	--	--	--	--	--	--	--
Medium Dose	12.06	-199	48,500	--	--	--	--	--	--	--
High Dose	12.25	-211	91,740	--	--	--	--	--	--	--
HEAT-ACTIVATED SODIUM PERSULFATE TEST										
Control	6.57	34	11,170	--	--	--	--	--	--	--
Low Dose	6.18	48	19,040	--	--	--	--	--	--	--
Medium Dose	6.02	57	36,150	--	--	--	--	--	--	--
High Dose	5.37	99	55,300	--	--	--	--	--	--	--
SOLID PHASE (concentrations in mg/Kg)										
						TOC (mg/Kg)	Total Iron (mg/Kg)	Manganese (mg/Kg)		
INITIAL COND.	--	--	--	--	--	1,190	5,640	136	--	--

Notes:

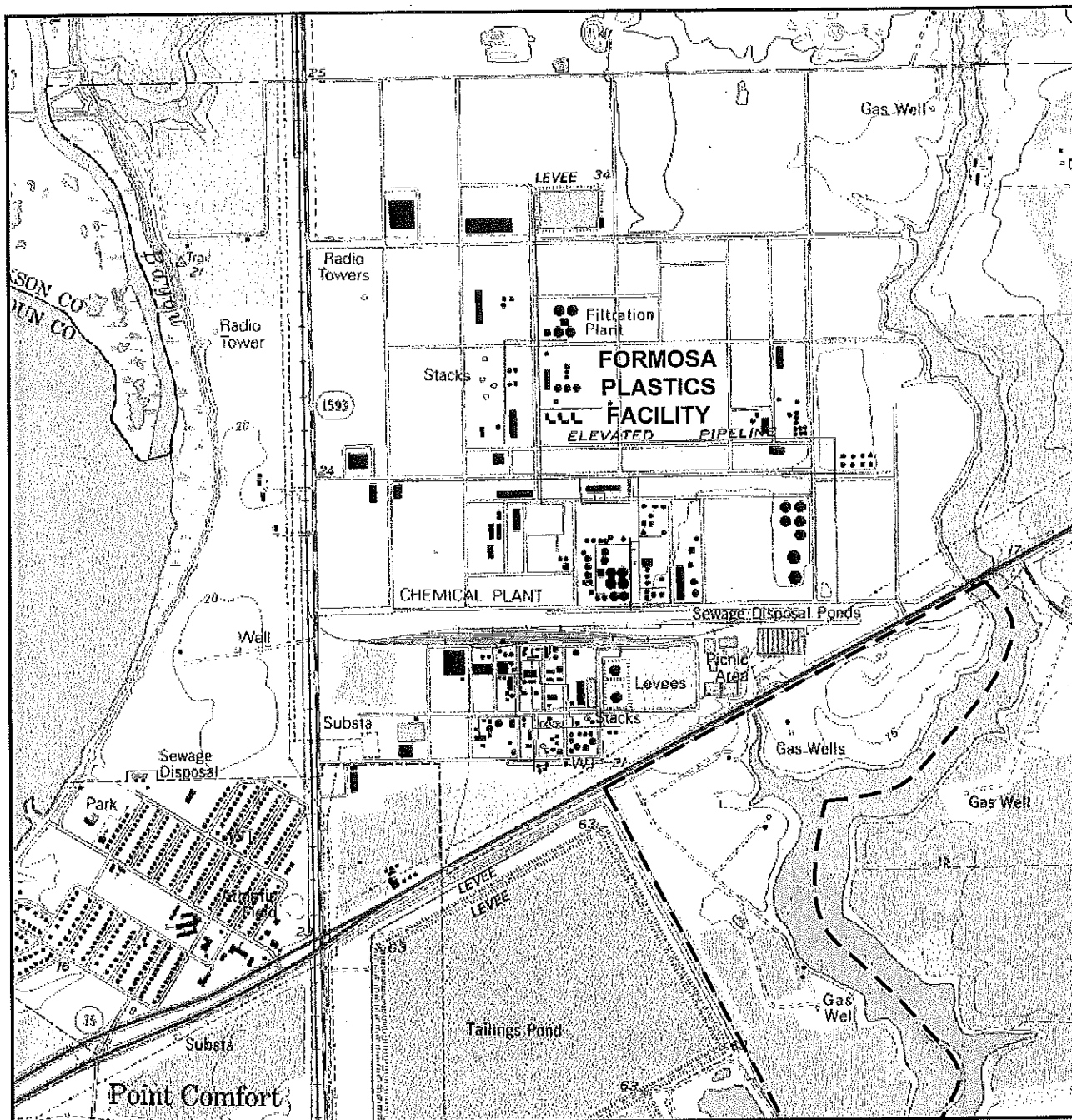
- 1) See ISOTEC report (Appendix B) for complete data and discussion.

TABLE 3. ENHANCED BIOREMEDIATION TEST DATA SUMMARY – EDC AND VOCs

TEST RESULTS (concentrations in ug/L)				
	EDC	TOTAL VOCs	EDC REDUCTION	VOC REDUCTION
INITIAL CONDITIONS				
Groundwater	1,400,000	1,554,800	--	--
Soil	38,000	40,312	--	--
WATER CONTROL MICROCOSMS				
Time Zero (Ambient)	1,500,000	1,623,600	--	--
Day 28	1,200,000	1,335,500	20% ⁽²⁾	17.7%
Day 56	1,400,000	1,530,000	6.7%	5.8%
Day 99	1,100,000	1,168,200	26.7%	28%
AMBIENT CONTROL MICROCOSMS				
Time Zero (Ambient)	1,500,000	1,623,600	--	--
Day 28	1,100,000	1,243,100	26.7% ⁽²⁾	23.5%
Day 56	1,300,000	1,419,400	13.3%	12.6%
Day 99	1,400,000	1,520,000	6.7%	6.4%
EHC TREATMENT MICROCOSMS				
Time Zero (Ambient)	1,500,000	1,623,600	--	--
Day 28	990,000	1,090,300	10% ⁽³⁾	12.3%
Day 56	1,100,000	1,162,030	15.4%	18.1%
Day 99 ⁽⁴⁾	930,000	974,800	33.6%	35.9%

Notes:

- 1) See FMC report (Appendix C) for complete data and discussion.
- 2) Percent reduction in the water and ambient control microcosms was calculated by dividing the concentration into the time zero ambient control concentration.
- 3) Percent reduction in the EHC treatment microcosm was calculated by dividing the concentration into the corresponding ambient control microcosm concentration.
- 4) After bioaugmentation of the EHC microcosm.



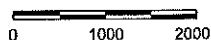
Contour Interval = 5 Feet



QUADRANGLE LOCATION



Scale in Feet



FORMOSA PLASTICS CORPORATION

Figure 1

AREA LOCATION MAP

PROJECT: 3251

BY: AJD

REVISIONS

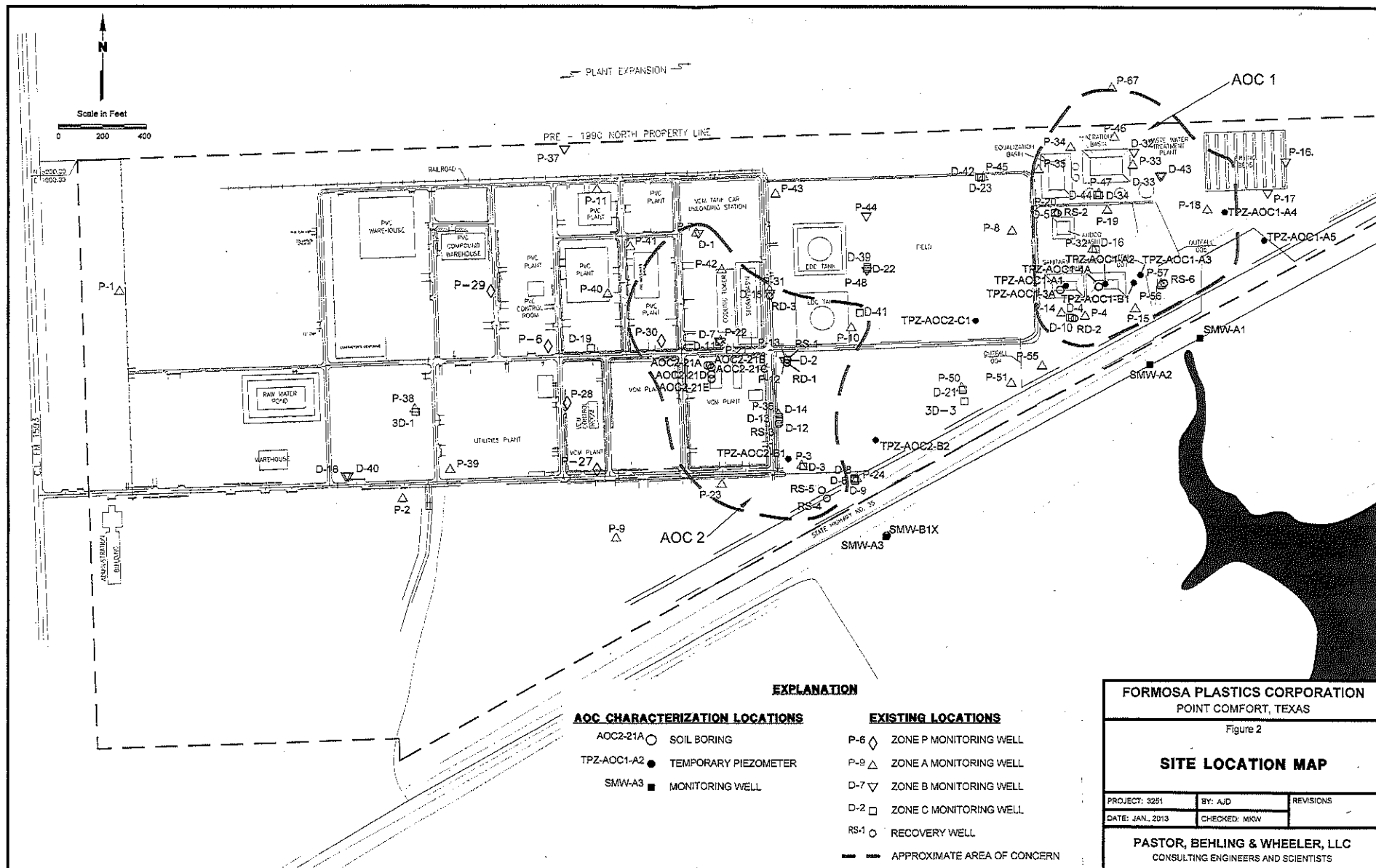
DATE: JAN., 2013

CHECKED: MKW

PASTOR, BEHLING & WHEELER, LLC
CONSULTING ENGINEERS AND SCIENTISTS

Source:

Base map from Point Comfort, Texas 7.5 min. U.S.G.S. quadrangle (1995).



APPENDIX A
Boring Log for TS-1

FORMOSA PLASTICS CORPORATION, TEXAS

Log of Boring: TS-1 (a,b,c,d)

201 FORMOSA DRIVE
POINT COMFORT, TEXAS

Completion Date:	9/4/2012	Drilling Method:	GeoProbe-Sonic
Drilling Company:	Walker-Hill	Borehole Diameter (in.):	4"
Driller:	Sammy V. Barnes, Jr.	Total Depth (ft):	20'
Driller's License:	59265	Northing:	13441469.579
Field Supervisor:	Kevin Dworsky	Easting:	2758180.838
Sampling Method:	4" Hollow Core	Ground Elev. (ft AMSL):	NA

PBW PROJECT No.: 3255

Depth (ft)	Well Materials	PID (ppm-v)	(ft/ft) Recovery	USCS	Lithologic Description
0				OL	0.0-2.9 - Sandy clay, black, abundant organic material, stiff, homogeneous, diffused boundary, moist, hard, medium plasticity
2					
4			9.8/10.0	CL	2.9-11.9 - Sandy clay, reddish tan, abundant small caliche nodules on top half of section, some black staining, some gray clay lenses, fine grained sand, clear boundary, moist, hard, medium plasticity
6					
8					
10					
12				SM	11.9-13.6 - Silty sand, tan, abundant silt, some reddish clay nodules, traces of organic material, clear boundary, wet, soft, rapid dilatancy, no plasticity
14			10.0/10.0	CH	13.6-20.0 - Silty clay, reddish tan, traces of fine sand, some black staining, some small caliche nodules, some gray clay veins, moist, very hard, high plasticity
16					
18					
20					

PBWPastor, Behling & Wheeler, LLC
620 E. Airline
Victoria, TX 77901
Tel (361) 573-6442 Fax (361) 573-6449

Notes:

APPENDIX B
ISOTEC Report - ISCO



BENCH SCALE TREATABILITY STUDY REPORT

FORMOSA PLASTICS CORPORATION
POINT COMFORT, TEXAS

JANUARY 11, 2013

PREPARED FOR

PASTOR, BEHLING & WHEELER, LLC
620 E. AIRLINE ROAD
VICTORIA, TEXAS 77901

ISOTEC PROJECT No. 901132

In-Situ Oxidative Technologies, Inc.
6452 Fig Street, Suite C
Arvada, Colorado 80004
Phone: (303) 843-9079, Fax: (303) 843-9094
WWW.INSITUOXIDATION.COM

SBA Certified Small Business



TABLE OF CONTENTS

1.0	EXECUTIVE SUMMARY.....	1
2.0	BENCH SCALE STUDY OBJECTIVES	4
3.0	SAMPLE COLLECTION AND PREPARATION.....	5
4.0	EXPERIMENTAL PROCEDURES.....	6
4.1	REAGENT IDENTIFICATION.....	6
4.2	ESTABLISHING EXPERIMENTAL CONTROLS.....	6
4.3	EXPERIMENTAL SETUP.....	6
4.4	REAGENT APPLICATIONS	7
4.4.1	<i>MFR-test</i>	7
4.4.2	<i>ASP-alk-test</i>	7
4.4.3	<i>ASP-heat-test</i>	7
4.5	ANALYTICAL SAMPLE COLLECTION AND ANALYSES.....	8
5.0	RESULTS AND DISCUSSION	10
5.1	INITIAL CHARACTERISTICS	10
5.2	EXPERIMENT RESULTS	11
5.2.1	<i>MFR-test (Table 2)</i>	11
5.2.2	<i>ASP-alk-test (Table 3)</i>	12
5.2.3	<i>ASP-heat-test (Table 4)</i>	13
5.2.4	<i>Results and Discussion</i>	13
6.0	CONCLUSIONS AND RECOMMENDATIONS.....	14

TABLES

TABLE 1 INITIAL CHARACTERIZATION
TABLE 2 TREATABILITY STUDY RESULTS (MFR)
TABLE 3 TREATABILITY STUDY RESULTS (ASP-ALK)
TABLE 4 TREATABILITY STUDY RESULTS (ASP-HEAT)

ATTACHMENTS

ATTACHMENT A BENCH STUDY ANALYTICAL DATA PACKAGES
--------------	--

ACRONYMS

ASP	Activated sodium persulfate
ASP-alk	Alkali activated sodium persulfate
ASP-heat	Heat activated sodium persulfate
COCs	Constituents of concern
expt	Experiment
g	gram
g/kg	Grams per kilogram
GW	Groundwater
IAL	Integrated Analytical Laboratories, LLC
ISCO	In-situ chemical oxidation
ISOTEC	In-Situ Oxidative Technologies, Inc.
Lbs	Pounds
MFR	Modified Fenton's Reagent
mg/kg	Milligrams per kilogram
mg	milligram
ml	milliliter
mV	milli volt
NaOH	Sodium hydroxide
Na ₂ S ₂ O ₈	Sodium persulfate
ND	Non detect concentration
PBW	Pasto, Behling & Wheeler, LLC
ppm	Parts per million
TDS	Total dissolved solids
TOC	Total organic carbon
TOD	Total oxidant demand
ug/kg	Micrograms per kilogram
µg/L	Micrograms per liter
VOC	Volatile organic compound

1.0 EXECUTIVE SUMMARY

In-Situ Oxidative Technologies, Inc. (ISOTECSM) was retained by Pastor, Behling & Wheeler, LLC (PBW) to conduct an in-situ chemical oxidation (ISCO) bench-scale laboratory treatability study (study) on soil and groundwater (GW) samples collected from the Formosa Plastics Corporation (Formosa) site located in Point Comfort, Texas. The target constituents for the study are volatile organic compounds (VOCs), and the constituent of concern (COC) at the site is 1,2-dichloroethane (EDC). Reagents evaluated during the study were modified Fenton's reagent (MFR) and sodium persulfate activated with alkali (ASP-alk) and heat (ASP-heat). The objective of the bench scale study was to evaluate the potential effectiveness of MFR, ASP-alk and ASP-heat in the treatment of EDC impacted soil and groundwater at the site. In addition, total oxidant demand (TOD) for ASP (measured as sodium persulfate) were also evaluated. TOD for MFR was not performed as consumption of hydrogen peroxide (by the activating agent in the MFR reagent to generate hydroxyl free radicals) is nearly 100% in most cases.

PBW collected soil and GW samples from the site and shipped them to ISOTEC for use during the treatability study. Prior to initiating the study, soil and groundwater were first composited, and a portion of the composited soil and composited GW was then collected and submitted to Integrated Analytical Laboratories, LLC (IAL) for various chemical analyses to collect initial characteristics data of the samples.

The remaining composited soils and GW were prepared into a slurry form by mixing the composited soil with the GW at a soil-to-water ratio of 2:1 by weight. All experiments were performed on the 2:1 slurry samples. A total of three experiments were performed, one for each reagent. For each test, a total of four reactors were set up with one reactor serving as the "control" and the remaining three served as "treatment" reactors. Each reactor consisted of the exact same quantity of composited soil and groundwater prior to the start of the experiments. Reagents were evaluated at three doses as shown in the table below. The experiments were quenched upon the completion of the tests. All reactors were separated into aqueous and solid phases and submitted for various chemical analyses on each phase.

Experiment Summary

Oxidant dose	MFR-test	ASP-alk-test	ASP-heat-test
Low dose	6.6 g/kg	6 g/kg	6 g/kg
Medium dose	33.3 g/kg	30 g/kg	30 g/kg
High dose	66 g/kg	60 g/kg	60 g/kg
Test Duration	3 days	10 days	1 day

Note: Oxidant doses are presented as grams of oxidant per kilogram of soil being tested.

Results indicate that all three reagents were effective in treating EDC as well as other VOCs detected at the site. Summary results are presented below.

- Using MFR, EDC was treated from 470,000 micrograms per liter ($\mu\text{g/L}$) to 185,000 $\mu\text{g/L}$ following the low dose treatment, and further down to 30,600 $\mu\text{g/L}$ (medium dose) and 8,190 $\mu\text{g/L}$ (high dose) in the aqueous phase, and from 64.1 milligrams per kilogram (mg/kg) to 16.7 mg/kg (low dose) and 0.0063 mg/kg (high dose) in the solid phase. VOC reductions achieved were 60% (low dose), 93% (medium dose) and 98% (high dose) in the aqueous phase and 74% (low dose) and >99% (medium and high doses) in the solid phase.
- Using ASP-alk, EDC was treated from 652,000 $\mu\text{g/L}$ to 497,000 $\mu\text{g/L}$ (low dose), 86,100 $\mu\text{g/L}$ (medium dose) and 243 $\mu\text{g/L}$ (high dose) in the aqueous phase. In the solid phase, EDC was treated from 116 mg/kg to 12.8 mg/kg (medium dose) following a slight increase with the low dose application and further down to 0.06 mg/kg (high dose). VOC reductions achieved were 25% (low dose), 87% (medium dose) and >99% (high dose) in the aqueous phase and 89% (medium dose) and >99% (high doses) in the solid phase. TOD analyses indicated 26%-57% consumption of sodium persulfate ($\text{Na}_2\text{S}_2\text{O}_8$) applied during the 10 day test period with an oxidant demand of 3.42 g/kg for the low dose, 9 g/kg for the medium dose and 15.6 g/kg for the high dose.
- Using ASP-heat, a similar EDC/VOC reduction pattern to that of ASP-alk was observed. EDC was treated from 746,000 $\mu\text{g/L}$ to 568,000 $\mu\text{g/L}$ (low dose), 2,750 $\mu\text{g/L}$ (medium dose) and 200 $\mu\text{g/L}$ (high dose) in the aqueous phase. In the solid phase, EDC was treated from 74 mg/kg to 0.487 mg/kg (medium dose) following a slight increase with the low dose application and further down to 0.05 mg/kg (high doses). VOC reduction achieved were 25% (low dose), 95% (medium dose) and 98% (high dose) in the aqueous phase and 97% (medium dose) and 99% (high doses) in the solid phase. TOD analyses indicated 53%-72% consumption of $\text{Na}_2\text{S}_2\text{O}_8$ applied during the 1 day test period with an oxidant demand of 4.32 g/kg for the low dose, 18.9 g/kg for the medium dose and 31.8 g/kg for the high dose.
- One observation of the bench study data is unique and important. The reduction in concentration in both solid and aqueous phases was very limited in both low-dose persulfate applications, while the MFR low-dose application showed a 61% and 74% VOC reduction for aqueous and solid phase, respectively. Total contaminant mass reduction comes from a cumulative effect of multiple low-dose applications, as opposed to one large medium-dose application; due primarily to field injection limitations of reagent volume and concentration. It does not appear that multiple low-dose applications of activated persulfate will lead to a cumulative mass reduction, since individual low-dose applications are

relatively ineffective. However, multiple low-dose applications of MFR should produce a cumulative mass reduction.

2.0 BENCH SCALE STUDY OBJECTIVES

The objectives of the bench scale study are to:

- Evaluate the treatment effectiveness of MFR, ASP-alk and ASP-heat in the treatment of VOCs, primarily EDC.
- Determine the total oxidant demand (TOD) for ASP-alk and ASP-heat.

3.0 SAMPLE COLLECTION AND PREPARATION

PBW collected soil (TS-1) and GW (P-56) samples on Sept. 5, 2012 from the site and shipped them to the ISOTEC research facility for use during the treatability study. The samples were stored at $<4^{\circ}\text{C}$ during the shipment and at ISOTEC's facility until commencement of each test.

Prior to initiating the study, the soil and groundwater samples were composited. A portion of the composited soils and groundwater was collected for initial characterization. This included analyses of VOCs, total organic carbon (TOC), total iron and total manganese on soil and GW samples, and alkalinity, ferrous iron, nitrate, sulfate and total dissolved solids on the GW sample only.

The experiment samples were prepared by mixing the composited soil with the groundwater at a 2:1 soil to groundwater ratio by weight. The 2:1 ratio was selected to represent a soil matrix that resembles the saturated subsurface with groundwater pore volume representative of 33% porosity. The experiment samples were used to perform various experiments to evaluate the effectiveness of MFR, ASP-alk and ASP-heat.

All samples were submitted to IAL for analyses. TOD analysis was performed internally at the ISOTEC laboratory along with pH, oxidation-reduction potential (ORP) and total dissolved solids (TDS) measurements.

4.0 EXPERIMENTAL PROCEDURES

The bench-scale treatability study consisted of MFR-test, ASP-alk-test and ASP-heat-test. In general, each test comprised of the following 4 steps:

1. Reagent Identification,
2. Establishing experimental control,
3. Experimental setup, and
4. Sample analysis.

4.1 Reagent Identification

In accordance to the Treatability Study Proposal, MFR and ASP were to be evaluated in the study. Both MFR and ASP consisted of an oxidant and an activating agent. For MFR, the oxidant used is stabilized hydrogen peroxide (H_2O_2) and the activating agent used is ISOTEC's patented Catalyst Series 4260 (Cat-4260), which is a circum-neutral pH (e.g. 5-8) organometallic complex (chelated iron) with high mobility within the subsurface. For ASP, the oxidant used is sodium persulfate ($Na_2S_2O_8$) and the activating agent used is sodium hydroxide (NaOH) for ASP-alk, and heat ($60^\circ C$) for ASP-heat.

4.2 Establishing Experimental Controls

An experimental "control" sample was set up during each experiment to document the following:

- Reduction or changes in concentrations of the target constituents due to sample dilution by reagent volumes injected.
- Reduction in concentrations of the target constituents due to volatilization caused by room temperature test conditions for MFR and ASP-alk, and the heated conditions for ASP-heat.

The "control" sample was set up exactly the same way, remained at, and was subject to the same conditions as the associated "treatment" reactors. However, the "control" reactor received distilled water (DI) instead of reagent (see Section 4.4 below).

4.3 Experimental Setup

Each experiment was set up in four reactors, one served as the "control" reactor (see Section 4.2 above) and the remaining three reactors as "treatment" reactors to receive MFR and ASP reagents at three dosages (low, medium and high) by weight of soil in the slurry being tested.

The experiments were performed in 250 milliliter (ml) VOC-tight glass jars sealed with screw top caps fitted with Teflon septa to facilitate reagent injection and prevent contaminant volatilization during the experiments. Exactly 150 grams (g) of 2:1 slurry

(100 g of soil and 50 ml of groundwater) was introduced into each reactor. The reactors were set up in duplicates, with one set used for VOC analysis and the second set used for pH, ORP, TDS measurements and TOD monitoring of $\text{Na}_2\text{S}_2\text{O}_8$ concentrations.

4.4 Reagent Applications

4.4.1 MFR-test

For reagent application, a predetermined amount of MFR was injected into each "treatment" reactor as incremental doses and DI water was used to compensate the differences in reagent volumes applied between reactors. The final oxidant (H_2O_2) concentrations were 6.6 g/kg (low), 33.3 g/kg (medium) and 66 g/kg (high) by weight of soil in the slurry sample being tested.

The multiple dosage approach (incremental approach) was used to increase treatment efficiency, minimize gas formation (preventing volatilization) and the resulting pressure buildup. For this study, two, four and six injections were performed to achieve the final oxidant concentrations in low dose, medium dose and high dose reactors, respectively. A time gap of approximately eight hours was maintained between dosages. All reactors (control and treatment) were left under room temperature conditions and inverted exactly 10 times daily to gain maximum contact between the reagent and the sample matrix. The duration of the experiment was three days.

4.4.2 ASP-alk-test

The predetermined amount of $\text{Na}_2\text{S}_2\text{O}_8$ was applied into each "treatment" reactor in a single batch and DI water was used to compensate the difference in reagent volumes applied between reactors. The final oxidant ($\text{Na}_2\text{S}_2\text{O}_8$) concentrations were 6 g/kg (low dose), 30 g/kg (medium dose) and 60 g/kg (high dose) by weight of soil in the slurry sample being tested. The "control" reactor in each experiment received an equivalent volume of distilled water instead of reagent. Alkali activation was achieved by raising and maintaining the pH value of the sample contents in each "treatment" reactor to between 11 and 12 standard unit (su) via addition of NaOH. All reactors (control and treatment) were left under room temperature conditions and inverted exactly 10 times daily to gain maximum contact between the reagent and the sample matrix. The duration of the experiment was 10 days.

4.4.3 ASP-heat-test

Similar to the ASP-alk-test, the predetermined amount of $\text{Na}_2\text{S}_2\text{O}_8$ was applied into each "treatment" reactor in a single batch and DI water was used to compensate the difference of reagent volumes applied between reactors. The final oxidant ($\text{Na}_2\text{S}_2\text{O}_8$) concentrations were 6 g/kg (low dose), 30 g/kg (medium dose) and 60 g/kg (high dose) by weight of soil in the slurry sample being tested. The "control" reactor received an equivalent volume of distilled water instead of reagent. Heat activation was achieved

by placing all reactors (control and treatment) of both sets in a water bath with warm water to raise and maintain the temperature of the sample contents at 60°C. The duration of the experiment was one day to minimize the VOC loss under a raised temperature.

For all three tests, a quenching agent (i.e. bovine catalase for peroxide and sodium thiosulfate for sodium persulfate) was injected into each reactor to terminate the reaction at the end of the experiments. Reactors were quenched (even if all the oxidant was not consumed) to minimize COC loss associated with volatilization under room temperature or heated test conditions.

TOD analysis was performed in the corresponding duplicates internally at ISOTEC. The TOD was determined by measuring the initial oxidant measurements (i.e. time = 0 days) collected immediately after introducing the oxidant into each reactor to obtain a baseline starting oxidant concentration. The residual oxidant concentration was obtained at the specific quenching period. TOD is determined from the difference of initial oxidant concentration and the final oxidant concentration. For ASP, TOD was reported as "g/kg" of sodium persulfate. Sodium persulfate concentrations were measured using a CHEMetrics colorimetric testing kit. Final pH, ORP and TDS values were measured using a Myron test kit in the corresponding duplicates.

4.5 Analytical Sample Collection and Analyses

Upon experiment completion, sample contents in each reactor (control and treatment) were separated into aqueous and solid phases. Then analytical samples were collected from each phase and submitted for various analyses as indicated in the table below.

Laboratory Analytical Parameters Summary

Parameters	Initial Characteristics		MFR-test		ASP-alk-test		ASP-heat-test	
	GW	Soil	Aqueous phase	Solid phase	Aqueous phase	Solid phase	Aqueous phase	Solid phase
VOCs	x	x	x	x	x	x	x	x
Ferrous iron	x		x					
Total iron	x	x						
Total manganese	x	x						
Alkalinity	x							
TOC	x	x						
TDS	x							
Sulfate	x							
Nitrate	x							

IAL performed all chemical analyses associated with the bench-scale treatability study. The VOC analyses was performed using Method SW-846 624 (GW)/8260B (soil), TOC analysis was performed using EPA method modified Lloyd Kahn (soil)/5310C (GW), and total iron and manganese analysis was performed using EPA method 6020, ferrous iron using SM20 3500FeB, alkalinity using 2320B, nitrate using 4500NO3F and TDS using 2540C. Laboratory analytical data packages including chains of custody, and internal laboratory custody chronicle are included as Attachment A.

5.0 RESULTS AND DISCUSSION

Detailed bench-scale testing results (including the initial characteristics analyses and experiment results) are presented in Tables 1 through 4. Laboratory analytical data packages are provided in Attachment A. Initial characteristics results are discussed in Section 5.1 and experiment results are discussed in Sections 5.2.

5.1 Initial Characteristics

Initial characteristics results are presented in Table 1.

In the GW sample (P-56), EDC, the primary site COC, was detected at 1,280,000 µg/L. Another 10 VOCs including chloroform (81,600 µg/L), vinyl chloride (13,300 µg/L) and 1,1-DCA (8,400 µg/L) were also detected in the sample resulting in a cumulative VOC concentration at 1,408,780 µg/L. Total iron and manganese were detected at 8,710 µg/L and 7,930 µg/L, respectively, and ferrous iron was found at 4,960 µg/L. Based on ISOTEC's past experience, iron concentrations in the aqueous phase should be greater than 25,000 µg/L (typical range should be 25,000 to 100,000 µg/L) to serve as effective Fenton's catalyst and greater than 150,000 µg/L to serve as effective sodium persulfate catalyst. Manganese concentrations greater than 25,000 µg/L also have potential to promote Fenton-like reactions. TOC was detected at 8,540 µg/L. Alkalinity and sulfate were detected at 606,000 µg/L and 378,000 µg/L, respectively. Nitrate was found at a non-detectable (ND) level (<500 µg/L).

In the soil sample (Soil Comp), EDC was detected at 44.9 mg/kg. Other VOCs detected were chloroform at 2.1 mg/kg and tetrachloroethene (PCE) at 0.4 mg/kg resulting in a total VOC concentration of 47.4 mg/kg. Total iron and manganese were found to be 5,640 mg/kg and 136 mg/kg, respectively. Iron and manganese are present in soils as mostly oxyhydroxides and may promote some Fenton-like reactions, although they are generally unavailable to act as effective catalysts and can potentially result in oxidant wastage. Alkalinity, nitrate, ferrous iron, sulfate and TDS were not analyzed. TOC was detected at 1,190 mg/kg.

TOC in both soil and groundwater will consume oxidants and higher TOC means greater competition for the oxidants, which can result in significant oxidant scavenging. The TOC levels detected in site soils (1,190 mg/kg) and GW (8,540 µg/L) are expected to exert a moderate to high oxidant demand. Iron in its dissolved form, especially ferrous iron, present in groundwater is known to activate sodium persulfate and hydrogen peroxide. As noted previously, iron levels in the groundwater (i.e. 8,710 µg/L for total dissolved iron and 4,960 µg/L for ferrous iron) are lower than the minimum iron concentration requirement for proper activation of sodium persulfate and hydrogen peroxide. Therefore, external catalyst will be needed during field application of MFR and ASP.

5.2 Experiment Results

COC treatment effectiveness is evaluated by comparison of "treated" sample data with the associated "control" sample data. A comparison between the "initial" and "control" data was not made because the analyses were performed on different types of samples (i.e. the "initial" were soil or GW samples, and "control" samples were slurry samples separated into solid and aqueous phases for analyses). However, since the "initial" and "control" samples were both untreated samples, they generally contain similar levels of contamination when sample materials are uniform. The "initial" samples typically have a higher COC concentration compared to "control" since the "control" samples are diluted after addition of DI water and are also subject to the room or heated temperature test conditions similar to the "treated" samples (Section 4.4). *[It should be noted that all three "control" samples contained higher VOC levels in the solid phase than the initial soil sample (i.e. Soil Comp). This anomaly is most likely due to heterogeneous nature of the soil samples, which made it almost impossible to produce uniform samples for all the tests and could cause fluctuations in analytical results. The control samples were also mixed with site water containing high VOC concentrations and submitted to the experiment conditions.]* As discussed in Section 4.2, a "control" sample was set up for each test to document COC concentration changes due to addition of reagents and VOC loss under the room temperature or heated test conditions. The "control" samples were prepared in the same manner and underwent the same conditions as the corresponding "treated" samples but received zero dosage of reagent. Therefore, the differences in contaminant concentrations between "treated" samples and the associated "control" sample best represent the treatment effectiveness and the effectiveness of each reagent is evaluated by comparison of "treated" sample data with the associated "control" sample data.

For discussion purpose, all ND values are assumed to be equal to zero in the contaminant reduction calculation. As discussed previously, three reagent doses of MFR (6.6 g/kg, 33.3 g/kg, & 66 g/kg of hydrogen peroxide, respectively, for low, medium and high doses) and three reagent doses of ASP (6 g/kg, 30 g/kg, & 60 g/kg of sodium persulfate, respectively, for low, medium and high doses) were evaluated. Results are presented in Tables 2, 3 and 4 and discussed below for each area.

Results indicate that all three reagents were effective in treating VOCs including EDC with maximum reduction achieved by greater than 97% in the aqueous phase and greater than 99% in the solid phase. Detailed discussions are provided below for each test.

5.2.1 MFR-test (Table 2)

A decreasing trend in VOC concentrations is evident as reagent doses increased in both solid and aqueous phases. In the solid phase, EDC was reduced from 64.1 mg/kg to 16.7 mg/kg (74% reduction) following the low dose application. It was further reduced to

0.01 mg/kg (medium dose) and 0.006 mg/kg (high dose), an equivalent 99.9% reduction for both doses. In the aqueous phase, EDC concentrations decreased from 470,000 µg/L to 185,000 µg/L (low dose), 30,600 µg/L (medium dose) and 8,190 µg/L (high dose), an equivalent 60%, 93% and 98% reduction.

Similar to EDC, VOC reductions achieved were 73.7% (low dose) and 99.9% (medium and high doses) in the solid phase, and 59.9% (low dose), 93.3% (medium dose) and 98.0% (high dose) in the aqueous phase.

TOD was not evaluated for MFR. In the MFR process, hydrogen peroxide consumption is mainly associated with generation of hydroxyl free radicals (the main agent to attack the organic compounds) through ISOTEC catalyst (the activating agent). The activation of hydrogen peroxide by ISOTEC catalyst is very quick (within hours) and, in most cases very efficient resulting in a nearly 100% consumption of hydrogen peroxide, regardless of the amount of soil or contaminants present.

Final pH ranged between 6.63 and 7.15 with a control value of 6.51. ORP values were between 182 mV and 203 mV with a control value of 185 mV, and TDS ranged between 11 µg/L and 8,220 µg/L with a control value of 5,940 µg/L. Ferrous iron was found at ND (<40 µg/L) in all treatment reactors as well as the control reactor.

5.2.2 ASP-alk-test (Table 3)

In the solid phase, EDC slightly increased from 116 mg/kg to 124 mg/kg following the low dose application. This anomaly is most likely due to the heterogeneous nature of the soil as discussed above in Section 5.2. EDC reduction took place following both medium and high doses. EDC concentrations decreased from 116 mg/kg to 12.8 mg/kg and 0.06 mg/kg (high dose), an equivalent 89.0% and 99.9% reduction, respectively. In the aqueous phase, EDC reduced from 652,000 µg/L to 497,000 µg/L (low dose), 86,100 µg/L (medium dose) and 243 µg/L (high), an equivalent 23.8%, 86.8% and 99.9% reduction.

For total VOCs, reduction achieved in the solid phase was 88.9% following the medium dose application and 99.9% following high doses. In the aqueous phase, VOC reductions were 25.2% following the low dose, 86.7% following the medium dose application and 99.9% the high dose. The high dose achieved greater than 99% reduction of EDC and total VOCs in both solid and aqueous phases.

TOD measurements showed a Na₂S₂O₈ consumption of 3.42 g/kg for the low dose, 9 g/kg for the medium dose and 15.6 g/kg for the high dose over the 10-day period.

Final pH ranged between 11.36 and 12.25 with a control value of 6.6. ORP values were between -159 mV and -211 mV with a control value of 46 mV. TDS values were noted between 18.34 µg/L and 91.74 µg/L with a control value of 10.88 µg/L.

5.2.3 ASP-heat-test (Table 4)

Using heat activation, a similar EDC/VOC reduction pattern to that of alkali activation was observed. In the solid phase, EDC was slightly increased from 74 mg/kg to 75 mg/kg following the low dose application, most likely due to the heterogeneous nature of the soil. EDC then decreased from 74 mg/kg to 0.487 mg/kg (medium dose) and 0.053 mg/kg (high dose), an equivalent of 99.3% (medium dose) and 99.9% (high dose) reduction. In the aqueous phase, EDC concentrations decreased from 746,000 µg/L to 568,000 µg/L (low dose), 2,750 µg/L (medium dose) and 200 µg/L (high), an equivalent 23.9%, 99.6% and 99.9% reduction.

Total VOC reductions achieved were 97.2% (medium dose) and 98.7% (high dose) in the solid phase and 24.1% (low dose), 95.2% (medium dose) and 97.9% (high dose) in the aqueous phase. Therefore, both medium and high doses achieved 98% and greater EDC/VOC reduction.

TOD measurements indicated a 1-day $\text{Na}_2\text{S}_2\text{O}_8$ consumption of 4.32 g/kg for the low dose, 18.9 g/kg for the medium dose and 31.8 g/kg for the high dose.

Final pH ranged between 5.37 and 6.18 with a control value of 6.57. ORP values were between 48 mV and 99 mV with a control value of 34 mV, and TDS ranged between 19 µg/L and 55.3 µg/L with a control value of 11.1 µg/L.

5.2.4 Results and Discussion

In summary, all three reagents, MFR, ASP-alk and ASP-heat, were effective in treating EDC, the primary site COC, as well as other contaminants detected at the site. In general, using the medium dose, all three reagents were able to achieve 86% and greater EDC/VOC reduction, and using the high dose all three reagents produced approximately 98% EDC/VOC reduction. Among the three reagents, MFR achieved a higher EDC/VOC reduction compared to ASP-alk and ASP-heat at the low dose (60%-73% vs 23%), while ASP-alk produced best results at the high dose leaving the lowest residual VOC concentration in the aqueous phase (667 µg/L) compared to MFR (10,676 µg/L) and ASP-heat (16,900 µg/L).

6.0 CONCLUSIONS AND RECOMMENDATIONS

Results of the bench scale treatability study indicate that MFR, ASP-alk and ASP-heat are all effective towards treating EDC, the primary site COC by achieving greater than 98% EDC reduction in both aqueous and solid phases. The TOD measurements indicated an oxidant demand of $\text{Na}_2\text{S}_2\text{O}_8$ was 4.32 g/kg to 31.8 g/kg for ASP-heat, and 3.42 g/kg to 15.6 g/kg for ASP-alk.

Chemistry vs. Remediation

A bench scale treatability study can really only evaluate the oxidation "chemistry" of the various oxidants. The Formosa study evaluated the chemistry of MFR, ASP-alk and ASP-heat on the contaminants present in the site soil and groundwater, primarily EDC. In other words, can each oxidant treat the contaminants present? The answer is yes, each oxidant tested can reduce contaminant concentrations in soil and water under bench conditions.

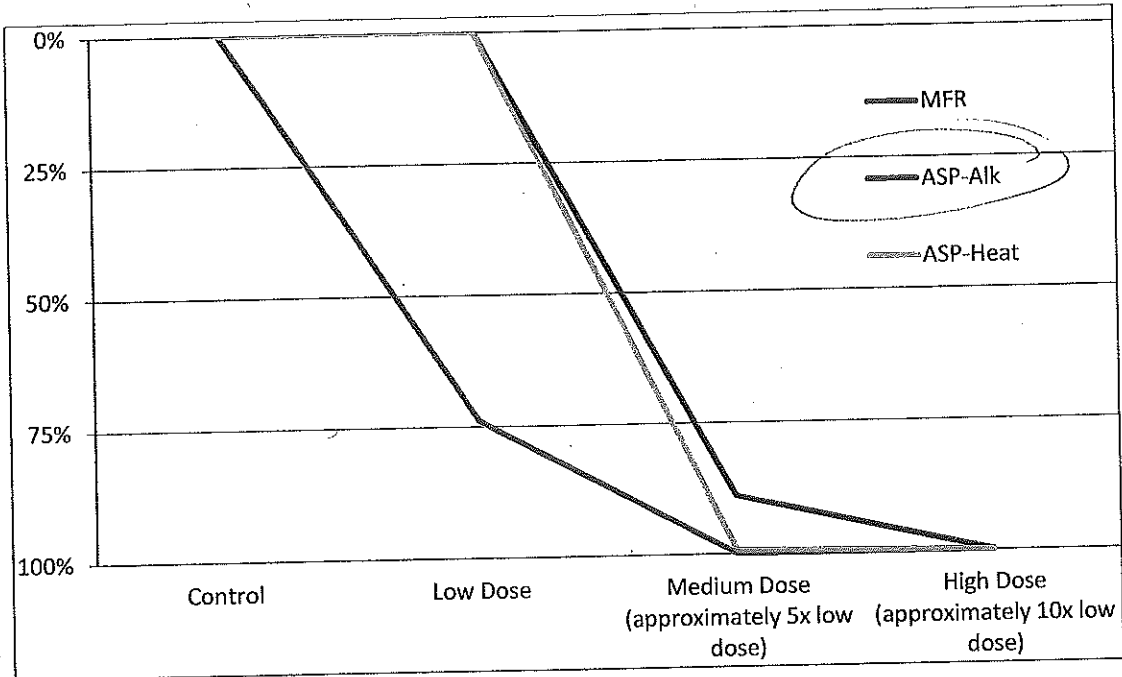
Bench conditions and in-situ conditions are completely different. The bench study started with a soil/water mixture of 2:1 by weight and the soil is comprised of individual particles in a water matrix with mixing. This mixture is an industry standard, but does not simulate in-situ conditions. In-situ conditions have a soil water mixture of approximately 5.8:1, assuming 30% porosity. In addition, the soil particles are compacted and mixing is impossible.

In-situ conditions present a unique set of obstacles to remediation implementation. Remediation is much more complex than bench study chemistry. Remediation requires the combination of injection pressures, volumes and flow rates; reagent type and concentration; and injection location spacing to achieve a uniform (as much as possible) distribution of reagents. Injectable reagent volumes are very site specific depending on grain size, degree of inter-bedded soil types, depth to water and previous penetrations. In general, reagent volumes are limited to 5-10% of a pore volume to prevent surfacing (escape of reagents from the subsurface to the ground). A deep saturated zone comprised of homogeneous gravel will accept a higher volume of reagent, but those conditions are rare. Oxidant concentrations are generally limited to less than 20% due to health and safety concerns regarding handling and surfacing.

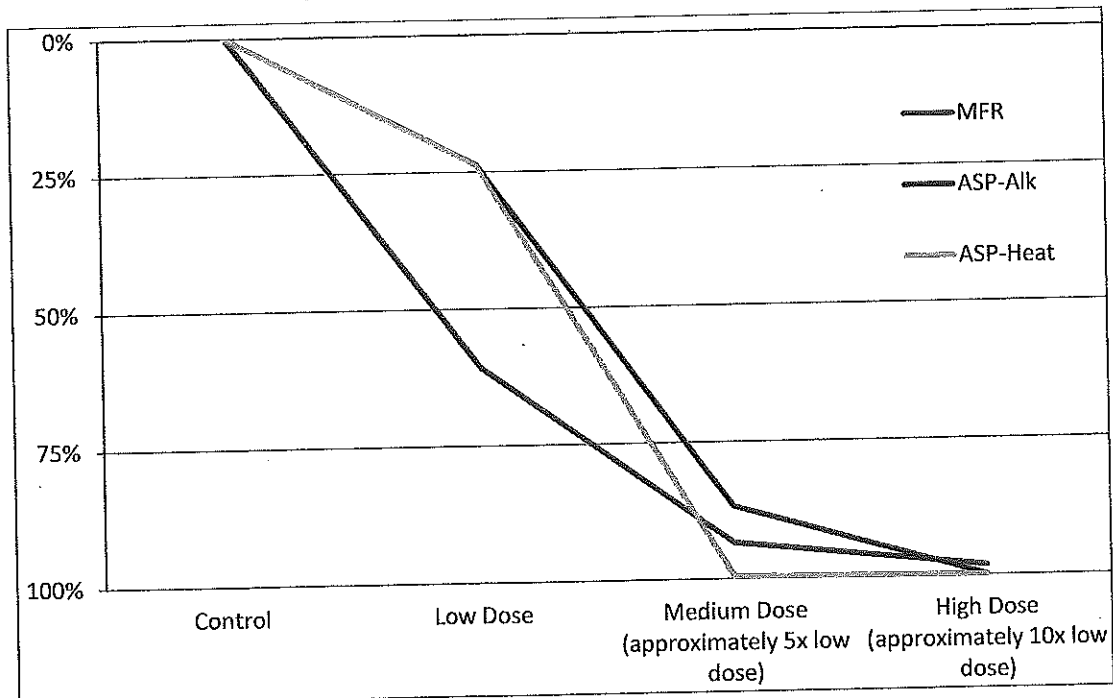
Remediation Recommendations

One observation of the bench study data is unique and important. The reduction in concentration in both solid and aqueous phases was very limited in both low-dose persulfate applications, while the MFR low-dose application showed a 61% and 74% VOC reduction for aqueous and solid phase, respectively (See graphs below).

Percent EDC Reduction, Solid Phase



Percent EDC Reduction, Aqueous Phase



Based on the discussion above regarding injectable volumes and concentrations, field applications at the site will mimic low-dose applications. Total contaminant mass reduction comes from a cumulative effect of multiple low-dose applications, as opposed to one large medium-dose application. It does not appear that multiple low-dose applications of activated persulfate will lead to a cumulative mass reduction, since individual low-dose applications are relatively ineffective. However, multiple low-dose applications of MFR should produce a cumulative mass reduction.

Based on the results of the bench study and the inherent application limitations, ISOTEC recommends a field pilot test utilizing MFR as the oxidant.

ISOTEC



TABLES

In-Situ Oxidative Technologies, Inc.

**Table 1. Initial Characterization
PBW/Formosa Plastics, Point Comfort, Texas
ISOTEC Project #901132**

Sample ID Matrix	P-56 Aqueous	Soil Comp Soil
VOCs	(ug/l)	(mg/kg)
Vinyl chloride	13,300	ND<0.298
1,1-Dichloroethene (1,1-DCE)	1,780	ND<0.298
trans-1,2-Dichloroethene	4,140	ND<0.298
1,1-Dichloroethane (1,1-DCA)	8,400	ND<0.298
cis-1,2-Dichloroethene	2,650	ND<0.298
Chloroform	81,600	2.1
1,2-Dichloroethane (EDC)	1,280,000	D 44.9
Benzene	2,920	ND<0.298
Trichloroethene	4,590	ND<0.298
1,1,2-Trichloroethane	7,330	0.404
Tetrachloroethene	2,070	ND<0.298
Total VOCs (ug/l)	1,408,780	47.4
Other Parameters	(ug/l)	(mg/kg)
Alkalinity	606,000	NA
Nitrate	ND<500	NA
Sulfate as SO4	378,000	NA
Total Organic Carbon (TOC)	8,540	1190
Total Dissolved Solids (TDS)	9,150,000	NA
Ferrous Iron	4,960	NA
Iron	8,710	5,640
Manganese	7,930	136

Note:

ug/l = micrograms per liter. mg/kg = milligrams per kilogram

ND = Compound was analyzed for but not detected at the reporting limit (RL)
indicated by the number following "<".

NA = Compound was not analyzed for.

D = The reported value is from a diluted analysis.

Table 2. Treatability Study Results (MFR)
PBW/Formosa Plastics, Point Comfort, Texas
ISOTEC Project #901132

Sample ID	M/Control	M/T-A	M/T-B	M/T-C
Catalyst Used	none	Cat-4260	Cat-4260	Cat-4260
Oxidant Used	none	H2O2	H2O2	H2O2
Oxidant Added (by weight)	0	6.6 g/kg	33.3 g/kg	66 g/kg
VOCs (ug/l)	Aqueous Phase			
Vinyl chloride	2,760	ND<1000	ND<250	ND<50
trans-1,2-Dichloroethene	1,520 J	ND<1000	ND<250	ND<50
1,1-Dichloroethane (1,1-DCA)	2,990	1,120	ND<250	ND<50
cis-1,2-Dichloroethene	ND<2500	ND<1000	ND<250	ND<50
Chloroform	37,200	20,500	3,770	2,070
1,2-Dichloroethane (EDC)	470,000	185,000	30,600	8,190
Benzene	ND<2500	ND<1000	ND<250	ND<50
Trichloroethene	1,690 J	ND<1000	ND<250	ND<50
1,1,2-Trichloroethane	3,730	2,140	744	416
Total VOCs (ug/l)	519,890	208,760	35,114	10,676
EDC reduction	-	60.64%	93.49%	98.26%
VOC reduction	-	59.85%	93.25%	97.95%
VOCs (mg/kg)	Solid Phase			
cis-1,2-Dichloroethene	ND<0.635	ND<0.124	ND<0.00121	ND<0.00125
Chloroform	2.54	0.779	ND<0.00121	ND<0.00125
1,2-Dichloroethane (EDC)	64.10	16.70	0.011	0.0063
1,1,2-Trichloroethane	0.43 J	0.18	0.0005 J	0.0005 J
Total VOCs (mg/kg)	67.1	17.7	0.01	0.01
EDC reduction	-	73.95%	99.98%	99.99%
VOC reduction	-	73.66%	99.98%	99.99%
Other Parameters				
ferrous Iron (ug/l)	ND<40.0	ND<40.0	ND<40.0	ND<40.0
Final pH value (SU)	6.51	6.63	6.90	7.15
Final ORP value (mV)	185	182	189	203
Final TDS value (ppm)	5,940	6,286	8,220	11,070

Note:

ug/l = micrograms per liter, mg/kg = milligrams per kilogram, g/kg = grams per kilogram, mV = milli volts.

ND = Compound was analyzed for but not detected at the reporting limit (RL) indicated

by the number following "<".

J = The concentration was detected at a value below the RL and above the method detection limit (MDL).

Total oxidant demand is presented as g/kg (grams of oxidant per kilogram of soil).

Table 3. Treatability Study Results (ASP-Alk)
PBW/Formosa Plastics, Point Comfort, Texas
ISOTEC Project #901132

Sample ID	S-A/Control	S-A/A	S-A/B	S-A/C
Catalyst Used	none	NaOH	NaOH	NaOH
Oxidant Used	none	Na ₂ S ₂ O ₈	Na ₂ S ₂ O ₈	Na ₂ S ₂ O ₈
Oxidant Added (by weight)	0	6 g/kg	30 g/kg	60 g/kg
VOCs (ug/l)	Aqueous Phase			
Vinyl chloride	ND<5000	3,010 J	3,700	396
trans-1,2-Dichloroethene	ND<5000	ND<5000	260 J	9.24
1,1-Dichloroethane (1,1-DCA)	2,720 J	1,910 J	539	3.42 J
cis-1,2-Dichloroethene	ND<5000	ND<5000	185 J	11.20
Chloroform	41,600	22,300	1,710	ND<5.0
1,2-Dichloroethane (EDC)	652,000	497,000	86,100	243
Benzene	ND<5000	ND<5000	ND<500	1.35 J
Trichloroethene	ND<5000	ND<5000	211 J	2.14 J
1,1,2-Trichloroethane	4,370 J	ND<5000	ND<500	ND<5.0
Tetrachloroethene	ND<5000	ND<5000	183 J	1.51 J
Total VOCs (ug/l)	700,690	524,220	92,888	667.86
EDC reduction	-	23.77%	86.79%	99.96%
VOC reduction	-	25.19%	86.74%	99.90%
VOCs (mg/kg)	Solid Phase			
Vinyl chloride	ND<0.611	ND<0.624	0.551	ND<0.121
1,1-Dichloroethane	0.416 J	0.469 J	0.076 J	ND<0.121
Chloroform	5.41	4.54	0.201	ND
1,2-Dichloroethane (EDC)	116	124	12.8	0.063 J
1,1,2-Trichloroethane	0.697	ND<0.624	ND<0.125	ND<0.121
Total VOCs (mg/kg)	122.52	129.01	13.63	0.06
EDC reduction	-	increase	88.97%	99.95%
VOC reduction	-	increase	88.88%	99.95%
% Oxidant Consumption	-	57%	30%	26%
Total Oxidant Demand (g/kg)	-	3.42	9.00	15.60
Other Parameters				
Final pH value (SU)	6.6	11.36	12.06	12.25
Final ORP value (mV)	46	-159	-199	-211
Final TDS value (ppm)	10,880	18,340	48,500	91,740

Note:

ug/l = micrograms per liter, mg/kg = milligrams per kilogram, g/kg = grams per kilogram, mV = milli volts.

ND = Compound was analyzed for but not detected at the reporting limit (RL) indicated by the number following "<"

J = The concentration was detected at a value below the RL and above the method detection limit (MDL).

Total oxidant demand is presented as g/kg (grams of oxidant per kilogram of soil).

Table 4. Treatability Study Results (ASP-Heat)
PBW/Formosa Plastics, Point Comfort, Texas
ISOTEC Project #901132

Sample ID	S-H/Control	S-H/A	S-H/B	S-H/C
Catalyst Used	Heat (60°C)	Heat (60°C)	Heat (60°C)	Heat (60°C)
Oxidant Used	none	Na ₂ S ₂ O ₈	Na ₂ S ₂ O ₈	Na ₂ S ₂ O ₈
Oxidant Added (by weight)	0	6 g/kg	30 g/kg	60 g/kg
VOCs (ug/l)	Aqueous Phase			
Chloromethane	ND<5000	ND<5000	1,150	571
Methylene chloride	ND<10000	ND<10000	9,420	4,490
1,1-Dichloroethane (1,1-DCA)	3,280 J	2,800 J	211	64.80 J
Chloroform	50,900	38,100	15,400	8,210
1,1,1-Trichloroethane (1,1,1-TCA)	ND<5000	ND<5000	143	107
Carbon tetrachloride	ND<5000	ND<5000	133	109
1,2-Dichloroethane (EDC)	746,000	568,000	2,750	200
Trichloroethene (TCE)	1,680 J	ND<5000	ND<100	ND<100
Bromodichloromethane	ND<5000	ND<5000	168	89.10 J
1,1,2-Trichloroethane (1,1,2-TCA)	4,860 J	3,340 J	8,310	2,650
Tetrachloroethene (PCE)	ND<5000	ND<5000	28.1 J	ND<100
1,1,2,2-Tetrachloroethane	ND<5000	ND<5000	659	410
Total VOCs (ug/l)	806,720	612,240	38,372	16,901
EDC reduction	-	23.86%	99.63%	99.97%
VOC reduction	-	24.11%	95.24%	97.90%
VOCs (mg/kg)	Solid Phase			
Methylene chloride	ND<1.22	ND<1.22	0.549	0.372
Chloroform	2.75	2.90	0.553	0.409
1,2-Dichloroethane (EDC)	74.00	75.00	0.487	0.053 J
1,1,2-Trichloroethane	0.491 J	0.503 J	0.585	0.176
Total VOCs (mg/kg)	77.24	78.40	2.17	1.01
EDC reduction	-	increase	99.34%	99.93%
VOC reduction	-	increase	97.19%	98.69%
% Oxidant Consumption	-	72%	63%	53%
Total Oxidant Demand (g/kg)	-	4.32	18.90	31.80
Other Parameters				
Final pH value (SU)	6.57	6.18	6.02	5.37
Final ORP value (mV)	34	48	57	99
Final TDS value (ppm)	11,170	19,040	36,150	55,300

Note:

ug/l = micrograms per liter, mg/kg = milligrams per kilogram, g/kg = grams per kilogram, mV = milli volts.
 ND = Compound was analyzed for but not detected at the reporting limit (RL) indicated by the number following "<".
 J = The concentration was detected at a value below the RL and above the method detection limit (MDL).
 Total oxidant demand is presented as g/kg (grams of oxidant per kilogram of soil).



ATTACHMENTS

(ATTACHMENT A: LABORATORY ANALYTICAL DATA PACKAGES)



ANALYTICAL DATA REPORT

for
Isotec
11 Princess Road
Suite A
Lawrenceville, NJ 08648

Project Name: PB&W/FORMOSA PLASTICS - 901132
Lab Case Number: E12-09138

RL = REPORTING LIMIT

MDL = METHOD DETECTION LIMIT

Volatiles

Lab ID: 09138-001
Client ID: P-56
Matrix-Units: Aqueous-ug/L
Percent Moisture: 100

Date Sampled: 9/10/2012
Time Sampled: 14:00
Date Analyzed: 9/12/12

Compound	Conc	Q	RL	MDL
Chloromethane	ND		1000	440
Vinyl chloride	13300		1000	580
Bromomethane	ND		1000	580
Chloroethane	ND		1000	620
Trichlorofluoromethane	ND		1000	640
Acrolein	ND		20000	4640
1,1-Dichloroethene	1780		1000	680
Methylene chloride	ND		4000	3960
Acrylonitrile	ND		20000	3880
tert-Butyl alcohol (TBA)	ND		2000	1720
trans-1,2-Dichloroethene	4140		1000	600
Methyl tert-butyl ether (MTBE)	ND		1000	460
1,1-Dichloroethane	8400		1000	440
cis-1,2-Dichloroethene	2650		1000	440
Chloroform	81600		1000	520
1,1,1-Trichloroethane	ND		1000	500
Carbon tetrachloride	ND		1000	540
1,2-Dichloroethane (EDC)	1280000	D	10000	5800
Benzene	2920		1000	460
Trichloroethene	4590		1000	540
1,2-Dichloropropane	ND		1000	440
Bromodichloromethane	ND		1000	420
2-Chloroethyl vinyl ether	ND		1000	660
cis-1,3-Dichloropropene	ND		1000	500
Toluene	ND		1000	660

ND = Analyzed for but Not Detected at the MDL

D = The compound was reported from the Diluted analysis

Continued on next page

273 Franklin Road
Randolph, NJ 07869
Phone: 973 361 4252
Fax: 973 989 5288



IAL is a NELAC New Jersey Certified Lab (14751) and maintains certification in Connecticut (PH-0699), New York (11402), Rhode Island (00126), Pennsylvania (68-00773) and in the Department of Navy IR QA Program

E12-09138



ANALYTICAL DATA REPORT

for
Isotec
11 Princess Road
Suite A
Lawrenceville, NJ 08648

Project Name: PB&W/FORMOSA PLASTICS - 901132
Lab Case Number: E12-09138

RL = REPORTING LIMIT

MDL = METHOD DETECTION LIMIT

Volatiles

Lab ID: 09138-001
Client ID: P-56
Matrix-Units: Aqueous-ug/L
Percent Moisture: 100

Date Sampled: 9/10/2012
Time Sampled: 14:00
Date Analyzed: 9/12/12

Compound	Conc	Q	RL	MDL
trans-1,3-Dichloropropene	ND		1000	580
1,1,2-Trichloroethane	7330		1000	600
Tetrachloroethene	2070		1000	420
Dibromochloromethane	ND		1000	680
Chlorobenzene	ND		1000	480
Ethylbenzene	ND		1000	620
Total Xylenes	ND		2000	1720
Bromoform	ND		1000	460
1,1,2,2-Tetrachloroethane	ND		1000	460
1,3-Dichlorobenzene	ND		1000	420
1,4-Dichlorobenzene	ND		1000	480
1,2-Dichlorobenzene	ND		1000	480
TOTAL VO's:	1380000			

General Analytical

Lab ID: 09138-001
Client ID: P-56
Percent Moisture: 100

Date Sampled: 9/10/2012
Time Sampled: 14:00

Parameter	Result	RL	MDL	Matrix-Units	Date Analyzed
Alkalinity	606000	8000	4400	Aqueous-ug/L	9/12/2012 12:00
Nitrate	ND	500	299	Aqueous-ug/L	9/11/2012 12:36
Sulfate as SO4	378000	125000	38500	Aqueous-ug/L	9/13/2012 12:15
Total Organic Carbon	8540	1000	460	Aqueous-ug/L	9/19/2012 8:45
Total Dissolved Solids	9150000	1250000	175000	Aqueous-ug/L	9/11/2012 10:00
Ferrous Iron	4960	200	40.0	Aqueous-ug/L	9/12/2012 16:45

ND = Analyzed for but Not Detected at the MDL

273 Franklin Road
Randolph, NJ 07869
Phone: 973 361 4252
Fax: 973 989 5288



IAL is a NELAC New Jersey Certified Lab (14751) and maintains certification in Connecticut (PH-0699), New York (11402), Rhode Island (00126), Pennsylvania (68-00773) and in the Department of Navy IR QA Program

E12-09138



ANALYTICAL DATA REPORT

for
Isotec
11 Princess Road
Suite A
Lawrenceville, NJ 08648

Project Name: PB&W/FORMOSA PLASTICS - 901132
Lab Case Number: E12-09138

RL = REPORTING LIMIT

MDL = METHOD DETECTION LIMIT

Volatiles

Lab ID: 09138-002
Client ID: SOIL COMP
Matrix-Units: Soil-mg/Kg
Percent Moisture: 16.1

Date Sampled: 9/10/2012
Time Sampled: 14:00
Date Analyzed: 9/19/12

Compound	Conc	Q	RL	MDL
Chloromethane	ND		0.298	0.068
Vinyl chloride	ND		0.298	0.197
Bromomethane	ND		0.298	0.164
Chloroethane	ND		0.298	0.125
Trichlorofluoromethane	ND		0.298	0.140
Acrolein	ND		5.96	0.709
1,1-Dichloroethene	ND		0.298	0.247
Methylene chloride	ND		0.596	0.590
Acrylonitrile	ND		5.96	0.468
tert-Butyl alcohol (TBA)	ND		0.596	0.218
trans-1,2-Dichloroethene	ND		0.298	0.152
Methyl tert-butyl ether (MTBE)	ND		0.298	0.083
1,1-Dichloroethane	ND		0.298	0.122
cis-1,2-Dichloroethene	ND		0.298	0.110
Chloroform	2.10		0.298	0.110
1,1,1-Trichloroethane	ND		0.298	0.140
Carbon tetrachloride	ND		0.298	0.212
1,2-Dichloroethane (EDC)	44.9		0.298	0.072
Benzene	ND		0.298	0.072
Trichloroethene	ND		0.298	0.143
1,2-Dichloropropane	ND		0.298	0.110
Bromodichloromethane	ND		0.298	0.092
2-Chloroethyl vinyl ether	ND		0.298	0.104
cis-1,3-Dichloropropene	ND		0.298	0.078
Toluene	ND		0.298	0.068
trans-1,3-Dichloropropene	ND		0.298	0.066

ND = Analyzed for but Not Detected at the MDL

Continued on next page

273 Franklin Road
Randolph, NJ 07869
Phone: 973 361 4252
Fax: 973 989 5288



IAL is a NELAC New Jersey Certified Lab (14751) and maintains certification
In Connecticut (PH-0699), New York (11402), Rhode Island (00126),
Pennsylvania (68-00773) and in the Department of Navy IR QA Program

E12-09138



ANALYTICAL DATA REPORT

for
Isotec
11 Princess Road
Suite A
Lawrenceville, NJ 08648

Project Name: PB&W/FORMOSA PLASTICS - 901132
Lab Case Number: E12-09138

RL = REPORTING LIMIT

MDL = METHOD DETECTION LIMIT

Volatiles

Lab ID: 09138-002
Client ID: SOIL COMP
Matrix-Units: Soil-mg/Kg
Percent Moisture: 16.1

Date Sampled: 9/10/2012
Time Sampled: 14:00
Date Analyzed: 9/19/12

Compound	Conc	Q	RL	MDL
1,1,2-Trichloroethane	0.404		0.298	0.080
Tetrachloroethene	ND		0.298	0.149
Dibromochloromethane	ND		0.298	0.092
Chlorobenzene	ND		0.298	0.098
Ethylbenzene	ND		0.298	0.107
Total Xylenes	ND		0.596	0.206
Bromoform	ND		0.298	0.068
1,1,2,2-Tetrachloroethane	ND		0.298	0.072
1,3-Dichlorobenzene	ND		0.298	0.098
1,4-Dichlorobenzene	ND		0.298	0.083
1,2-Dichlorobenzene	ND		0.298	0.098
TOTAL VO's:	47.4			

Metals

Lab ID: 09138-002
Client ID: SOIL COMP
Matrix-Units: Soil-mg/Kg
Percent Moisture: 16.1

Date Sampled: 9/10/2012
Time Sampled: 14:00
Date Analyzed: 9/14/12

Parameter	Result	Q	RL	MDL
Iron	5640		31.8	15.9
Manganese	136		1.27	0.318

ND = Analyzed for but Not Detected at the MDL

273 Franklin Road
Randolph, NJ 07868
Phone: 973 361 4252
Fax: 973 989 5288



IAL is a NELAP New Jersey Certified Lab (14751) and maintains certification in Connecticut (PH-0699), New York (11402), Rhode Island (00126), Pennsylvania (88-00773) and in the Department of Navy IR QA Program

E12-09138



ANALYTICAL DATA REPORT

for
Isotec
11 Princess Road
Suite A
Lawrenceville, NJ 08648

Project Name: PB&W/FORMOSA PLASTICS - 901132
Lab Case Number: E12-09138

RL = REPORTING LIMIT

MDL = METHOD DETECTION LIMIT

General Analytical

Lab ID: 09138-002
Client ID: SOIL COMP
Percent Moisture: 16.1

Date Sampled: 9/10/2012
Time Sampled: 14:00

Parameter	Result	RL	MDL	Matrix-Units	Date Analyzed
Total Organic Carbon	1190	1000	376	Soil-mg/Kg	9/18/2012 9:15


Metals

Lab ID: 09138-003
Client ID: P-56 FILT.
Matrix-Units: Aqueous-ug/L
Percent Moisture: 100

Date Sampled: 9/10/2012
Time Sampled: 14:00
Date Analyzed: 9/12/12

Parameter	Result	Q	RL	MDL
Iron	8710		100	50.0
Manganese	7930		4.00	2.00

These data have been reviewed and accepted by:


Michael H. Leftin, Ph.D.
Laboratory Director

273 Franklin Road
Randolph, NJ 07869
Phone: 973 361 4252
Fax: 973 989 5288



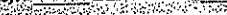



IAL is a NELAC New Jersey Certified Lab (14751) and maintains certification in Connecticut (PH-0699), New York (11402), Rhode Island (00126), Pennsylvania (68-00773) and in the Department of Navy IR QA Program

E12-09138

CUSTOMER INFO				REPORTING INFO				Turnaround Time (start the following day, if samples rec'd at lab > 5PM)																							
Company: ISOTEC - Lawrenceville, GA				REPORT TO:				*Lab notification is required for RUSH TAT prior to sample arrival. RUSH TAT IS NOT GUARANTEED WITHOUT LAB APPROVAL. **RUSH SURCHARGES WILL APPLY IF ABLE TO ACCOMMODATE																							
Address:				Address:				PHC - MUST CHOOSE NJ EPH DRO (5 day TAT) NJ EPH Fractionated (5 day TAT) NJ EPH - C40 (5 day TAT) DRO-8015 (3-5 day TAT) QAM025 (5 day TAT)								Rush TAT Charge ** 24 hr - 100%... 48 hr - 75%... 72 hr - 50%... 96 hr - 35%... 5 day - 25%... 6-9 day 10%		Report Format		EDDs											
Telephone #:				Attn:														Results Only		NJ SRP format											
Fax #:				FAX #												Reduced		NYSDEC													
Project Manager: Prasad Kakarla				INVOICE TO:												Regulatory - 15% Surcharge applies		lab approved custom EDD													
EMAIL Address:				Address:												Other (describe)		NO EDD/CD REQ'D													
Sampler: Yan Chin																Cooler Temp 4 °C															
Project Name: PBW/ Formosa Plastic																															
Project Location (State): TX				Attn:																											
Bottle Order #:				PO # 4254				Hard Copy: Std 3 week * Other - call for price																							
Quote #: 901132				Sample Matrix DW - Drinking Water AQ - Aqueous WW - Waste Water OI - Oil LIQ - Liquid (Specify) OT - Other (Specify) S - Soil SL - Sludge SOL - Solid W - Wipe				ANALYTICAL PARAMETERS VOCs TOC Fe Sulfate Nitrate TDS Mn Alkalinity												# BOTTLES & PRESERVATIVES											
Client ID		Depth (ft only)		Sampling		Matrix		# container		IAL #																					
				Date		Time																									
P-56				9/10/12		2pm		AQ		3		1		X		X		X		X		X		X		X		X		X	
Soil Comp				9/10/12		2pm		S		2		2		X		X		X													
40-ml slurry contains: 20g-soil, 20 ml-MeOH																															
Known Hazard: Yes or No		Describe:		Conc. Expected:		Low Med High		MDL Req: GWQS (11/05) - SRS - SRS/IGW - SRS Residential - OTHER (SEE COMMENTS)																							

Please print legibly and fill out completely. Samples cannot be processed and the turnaround time will not start until any ambiguities have been resolved.

Carrier (check one): <input checked="" type="checkbox"/> IAL Courier <input type="checkbox"/> Client Courier <input type="checkbox"/> FedEx/UPS					
Signature/Company	Date	Time	Signature/Company	Date	Time
Relinquished by: 	9/10/12	2pm	Received by:  IAC	9/10/12	14:00
Relinquished by:  IAC	9/10/12	16:11	Received by: 	9/10/12	16:11
Relinquished by:			Received by:		
Relinquished by:			Received by:		
Relinquished by:			Received by:		

Comments: Use lowest MDL possible.

Lab Case #

09138

PAGE: 1 of 1

LAB COPIES - WHITE & YELLOW; CLIENT COPY - PINK

1A2012 REV COC

01/2012 rev

PROJECT INFORMATION



Case No. **E12-09138** Project **PB&W/FORMOSA PLASTICS - 901132**

Customer **Isotec**

P.O. # **4254**

Contact **Prasad Kakarla**

Received **9/10/2012 16:11**

E-Mail **pkakarla@insituoxidation.com;** ☒ EMail EDDs

Verbal Due **9/24/2012**

Phone **(609) 275-8500** Fax **1(609) 275-9608**

Report Due **10/1/2012**

Report To

Bill To

11 Princess Road

11 Princess Road

Suite A

Suite A

Lawrenceville, NJ 08648

Lawrenceville, NJ 08648

Attn: Prasad Kakarla

Attn: Prasad Kakarla

Report Format Result Only

Additional Info ☐ State Form ☐ Field Sampling ☐ Conditional VOA

Lab ID	Client Sample ID	Depth Top / Bottom	Sampling Time	Matrix	Unit	# of Containers
09138-001	P-56	n/a	9/10/2012@14:00	Aqueous	ug/L	3
09138-002	SOIL COMP	n/a	9/10/2012@14:00	Soil	mg/Kg	2
09138-003	P-56 FILT.	n/a	9/10/2012@14:00	Aqueous	ug/L	

Sample #	Tests	Status	QA Method
001	PP VO + Cis 1,2-DCE + MTBE TBA	In Process	624
"	Metals Filtration	Complete	
"	Alkalinity	Run	2320B
"	Ferrous (II) Iron	Run	SM20 3500 Fe B
"	NO3 (Nitrate)	Run	4500NO3F
"	Sulfate (SO4)	Run	D516
"	TDS (Dissolved)	Run	2540C
"	TOC	Run	5310C
002	PP VO + Cis 1,2-DCE + MTBE TBA	Run	8260B
"	Iron - Fe	Run	6020
"	Manganese - Mn	Run	6020
"	TOC	Run	Mod Lloyd-Kahn
003	Iron - Fe	In Process	6020
"	Manganese - Mn	In Process	6020

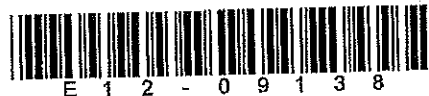
09/11/2012 08:54 by Ellen - NOTE 1

SOIL VO CONTENTS: 20g SOIL/20ml MEOH

09/11/2012 13:12 by Mark - NOTE 2

USE LOWEST MDL'S POSSIBLE

PROJECT INFORMATION



Case No. **E12-09138**

Project **PB&W/FORMOSA PLASTICS - 901132**

09/12/2012 16:26 by melissa - REV 1

AS PER YAN CHIN, RUN SAMPLE 001 FOR FERROUS IRON.

INTEGRATED ANALYTICAL LABORATORIES, LLC

SAMPLE RECEIPT VERIFICATION

CASE NO: E 12

09138

CLIENT:

ISOTEC

COOLER TEMPERATURE: 2° - 6°C: ☒

(See Chain of Custody)

Comments

COC: COMPLETE / INCOMPLETE

KEY

✓ = YES/NA

✗ = NO

✓ Bottles Intact

✓ no-Missing Bottles

✓ no-Extra Bottles

✓ Sufficient Sample Volume

✓ no-headspace/bubbles in VOs

✓ Labels intact/correct

✓ pH Check (exclude VOs)¹

✓ Correct bottles/preservative

✓ Sufficient Holding/Prep Time¹

☐ Sample to be Subcontracted

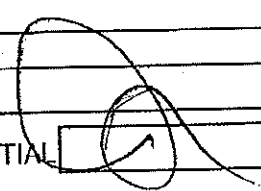
✓ Chain of Custody is Clear

¹ All samples with "Analyze Immediately" holding times will be analyzed by this laboratory past the holding time. This includes but is not limited to the following tests: pH, Temperature, Free Residual Chlorine, Total Residual Chlorine, Dissolved Oxygen, Sulfite.

ADDITIONAL COMMENTS:

SAMPLE(S) VERIFIED BY:

INITIAL



DATE

9/10/12

CORRECTIVE ACTION REQUIRED:

YES

☐

(SEE BELOW)

NO

☐

If COC is **NOT** clear, **STOP** until you get client to authorize/clarify work.

CLIENT NOTIFIED:

YES

☐

Date/ Time:

NO

☐

PROJECT CONTACT:

SUBCONTRACTED LAB:

DATE SHIPPED:

ADDITIONAL COMMENTS:

VERIFIED/TAKEN BY:

INITIAL



DATE

9.11.12

REV 03/2009-09138

Laboratory Custody Chronicle

IAL Case No.

E12-09138

Client Isotec

Project PB&W/FORMOSA PLASTICS - 901132

Received On 9/10/2012@16:11

			<u>Prep. Date</u>	<u>Analyst</u>	<u>Analysis Date</u>	<u>Analyst</u>
Department: Volatiles						
PP VO + Cis 1,2-DCE + MTBE & TBA	09138-001	Aqueous	n/a	n/a	9/12/12	Sylvia
"	-002	Soil	n/a	n/a	9/19/12	Mei
Department: Metals						
Iron - Fe	-002	Soil	9/13/12	Lisa	9/14/12	En
"	-003	Aqueous	9/12/12	Lisa	9/12/12	En
Manganese - Mn	-002	Soil	9/13/12	Lisa	9/14/12	En
"	-003	Aqueous	9/12/12	Lisa	9/12/12	En
Department: Wet Chemistry						
Alkalinity	-001	Aqueous	n/a	n/a	9/12/12	Kris
Ferrous (II) Iron	-001	Aqueous	n/a	n/a	9/12/12@16:45	Kris
NO3 (Nitrate)	-001	Aqueous	n/a	n/a	9/11/12@12:36	Geeta
Sulfate (SO4)	-001	Aqueous	n/a	n/a	9/13/12	Debbie
TDS (Dissolved)	-001	Aqueous	n/a	n/a	9/11/12	Robert
TOC	-001	Aqueous	n/a	n/a	9/19/12	Elma
"	-002	Soil	n/a	n/a	9/18/12	Elma



ANALYTICAL DATA REPORT

Isotec
11 Princess Road
Suite A
Lawrenceville, NJ 08648

Project Name: **PB&W/FORMOSA PLASTICS - 901132**
IAL Case Number: **E12-09359**

These data have been reviewed and accepted by:

A handwritten signature in dark ink, appearing to read 'Michael H. Lefan'.

Michael H. Lefan, Ph.D.
Laboratory Director

This report shall not be reproduced, except in its entirety, without the written consent of Integrated Analytical Laboratories, LLC. The test results included in this report relate only to the samples analyzed.

273 Franklin Road
Randolph, NJ 07869
Phone: 973 361 4252
Fax: 973 989 5288



IAL is a NELAP New Jersey Certified Lab (14751) and maintains certification in Connecticut (PH-0699), New York (11402), Rhode Island (00126), Pennsylvania (68-00773) and in the Department of Navy IR QA Program

Sample Summary

IAL Case No.

E12-09359

Client Isotec

Project PB&W/FORMOSA PLASTICS - 901132

Received On 9/14/2012@17:30

<u>Lab ID</u>	<u>Client Sample ID</u>	<u>Depth Top/Bottom</u>	<u>Sampling Time</u>	<u>Matrix</u>	<u># of Container</u>
09359-001	M/CONTROL	n/a	9/14/2012	Aqueous	2
09359-002	M/A	n/a	9/14/2012	Aqueous	2
09359-003	M/B	n/a	9/14/2012	Aqueous	2
09359-004	M/C	n/a	9/14/2012	Aqueous	2
09359-005	M/CONTROL	n/a	9/14/2012	Soil	1
09359-006	M/A	n/a	9/14/2012	Soil	1
09359-007	M/B	n/a	9/14/2012	Soil	1
09359-008	M/C	n/a	9/14/2012	Soil	1

INTEGRATED ANALYTICAL LABORATORIES, LLC.

TABLE OF CONTENTS

	<u>Page</u>
Qualifiers	1
Results Summary Report	3
Analytical Results	
Volatiles	
General Analytical	
Ferrous (II) Iron	
Sample Tracking	12
Chains of Custody	
Project Information	
Sample Receipt Verification	
Laboratory Chronicle	
Last Page of the Report	16

This report was finalized on October 02, 2012

INTEGRATED ANALYTICAL LABORATORIES, LLC.

DEFINITIONS / QUALIFIERS

DATA QUALIFIERS

- B Indicates the analyte was found in the associated method blank as well as in the sample. It indicates probable laboratory contamination.
- C Indicates analyte is a common laboratory contaminant.
- D Indicated analyte was reported from diluted analysis.
- E Identifies a compound concentration that exceeds the upper level of the calibration range of the instrument for that specific analysis.
- J Indicates an estimated value. This flag is used when the concentration in the sample is below the RL but above the MDL.

REPORTING DEFINITIONS

- RL Reporting Limit. The RL is determined by the lowest concentration in the calibration curve. For most Wet Chemistry methods, the RL is defined by using the PQL.
- MDL Method Detection Limit as determined according to 40CFR Part 136 Appendix B.
- PQL Practical Quantitation Limit. Usually defined as a value 3-5 times the MDL.
- ND Indicates analyte was analyzed for but not detected above the MDL.
- DF Dilution Factor
- LCS Laboratory Control Sample
- LCSD Laboratory Control Sample Duplicate
- MS Matrix Spike
- MSD Matrix Spike Duplicate
- DUP Duplicate

INTEGRATED ANALYTICAL LABORATORIES, LLC.

SUMMARY REPORT

Client: Isotec

Project: PB&W/FORMOSA PLASTICS - 901132

Lab Case No.: E12-09359

Lab ID:	09359-001	09359-002	09359-003	09359-004
Client ID:	M/CONTROL	M/A	M/B	M/C
Matrix:	Aqueous	Aqueous	Aqueous	Aqueous
Sampled Date	9/14/12	9/14/12	9/14/12	9/14/12
PARAMETER(Units)	Conc Q MDL	Conc Q MDL	Conc Q MDL	Conc Q MDL
Volatiles (Units)	(ug/L-ppb)	(ug/L-ppb)	(ug/L-ppb)	(ug/L-ppb)
Vinyl chloride	2760 1600	ND 640	ND 160	ND 32.0
tert-Butyl alcohol (TBA)	ND 3450	ND 1380	ND 345	ND 69.0
trans-1,2-Dichloroethene	1520 J 1150	ND 460	ND 115	ND 23.0
Methyl tert-butyl ether (MTBE)	ND 1350	ND 540	ND 135	ND 27.0
1,1-Dichloroethane	2990 1300	1120 520	ND 130	ND 26.0
cis-1,2-Dichloroethene	ND 1300	ND 520	ND 130	ND 26.0
Chloroform	37200 1300	20500 520	3770 130	2070 26.0
1,2-Dichloroethane (EDC)	470000 1850	185000 740	30600 185	8190 37.0
Trichloroethene	1690 J 1150	ND 460	ND 115	ND 23.0
1,1,2-Trichloroethane	3730 1400	2140 560	744 140	416 28.0
TOTAL VO's:	520000 J	209000	35100	10700
General Analytical (Units)				
Ferrous (II) Iron(ug/L)	ND 40.0	ND 40.0	ND 40.0	ND 40.0
Lab ID:	09359-005	09359-006	09359-007	09359-008
Client ID:	M/CONTROL	M/A	M/B	M/C
Matrix:	Soil	Soil	Soil	Soil
Sampled Date	9/14/12	9/14/12	9/14/12	9/14/12
PARAMETER(Units)	Conc Q MDL	Conc Q MDL	Conc Q MDL	Conc Q MDL
Volatiles (Units)	(mg/Kg-ppm)	(mg/Kg-ppm)	(mg/Kg-ppm)	(mg/Kg-ppm)
tert-Butyl alcohol (TBA)	ND 0.463	ND 0.090	ND 0.0011	ND 0.00114
Methyl tert-butyl ether (MTBE)	ND 0.178	ND 0.035	ND 0.000278	ND 0.000288
cis-1,2-Dichloroethene	ND 0.235	ND 0.046	ND 0.000375	ND 0.000388
Chloroform	2.54 0.235	0.779 0.046	ND 0.000351	ND 0.000363
1,2-Dichloroethane (EDC)	64.1 0.152	16.7 0.030	0.011 0.000254	0.00632 0.000263
1,1,2-Trichloroethane	0.428 J 0.171	0.184 0.034	0.000502 J 0.000242	0.000455 J 0.00025
TOTAL VO's:	67.1 J	17.7	0.012 J	0.00678 J

ND = Analyzed for but Not Detected at the MDL

J = The concentration was detected at a value below the RL and above the MDL

All qualifiers on individual Volatiles & Semivolatiles are carried down through summation.

INTEGRATED ANALYTICAL LABORATORIES

VOLATILE ORGANICS

Lab ID: 09359-001
 Client ID: M/CONTROL
 Date Received: 09/14/2012
 Date Analyzed: 09/17/2012
 Data file: E5430.D

GC/MS Column: DB-624
 Sample wt/vol: 0.001mL
 Matrix-Units: Aqueous-µg/L (ppb)
 Dilution Factor: 5000
 % Moisture: 100

Compound	Concentration	Q	RL	MDL
Chloromethane	ND		2500	2450
Vinyl chloride	2760		2500	1600
Bromomethane	ND		2500	2450
Chloroethane	ND		2500	2000
Trichlorofluoromethane	ND		2500	1500
Acrolein	ND		50000	12600
1,1-Dichloroethene	ND		2500	1400
Methylene chloride	ND		10000	9900
Acrylonitrile	ND		50000	9050
tert-Butyl alcohol (TBA)	ND		5000	3450
trans-1,2-Dichloroethene	1520	J	2500	1150
Methyl tert-butyl ether (MTBE)	ND		2500	1350
1,1-Dichloroethane	2990		2500	1300
cis-1,2-Dichloroethene	ND		2500	1300
Chloroform	37200		2500	1300
1,1,1-Trichloroethane	ND		2500	1350
Carbon tetrachloride	ND		2500	1350
1,2-Dichloroethane (EDC)	470000		2500	1850
Benzene	ND		2500	1450
Trichloroethene	1690	J	2500	1150
1,2-Dichloropropane	ND		2500	1300
Bromodichloromethane	ND		2500	1150
2-Chloroethyl vinyl ether	ND		2500	2250
cis-1,3-Dichloropropene	ND		2500	1200
Toluene	ND		2500	850
trans-1,3-Dichloropropene	ND		2500	1600
1,1,2-Trichloroethane	3730		2500	1400
Tetrachloroethene	ND		2500	1100
Dibromochloromethane	ND		2500	2050
Chlorobenzene	ND		2500	1350
Ethylbenzene	ND		2500	1300
Total Xylenes	ND		5000	3300
Bromoform	ND		2500	2250
1,1,2,2-Tetrachloroethane	ND		2500	2150
1,3-Dichlorobenzene	ND		2500	2450
1,4-Dichlorobenzene	ND		2500	2450
1,2-Dichlorobenzene	ND		2500	2300

Total Target Compounds (37): 520000 J

INTEGRATED ANALYTICAL LABORATORIES

VOLATILE ORGANICS

Lab ID: 09359-002
 Client ID: M/A
 Date Received: 09/14/2012
 Date Analyzed: 09/17/2012
 Data file: E5447.D

GC/MS Column: DB-624
 Sample wt/vol: 0.0025mL
 Matrix-Units: Aqueous-µg/L (ppb)
 Dilution Factor: 2000
 % Moisture: 100

Compound	Concentration	Q	RL	MDL
Chloromethane	ND		1000	980
Vinyl chloride	ND		1000	640
Bromomethane	ND		1000	980
Chloroethane	ND		1000	800
Trichlorofluoromethane	ND		1000	600
Acrolein	ND		20000	5020
1,1-Dichloroethene	ND		1000	560
Methylene chloride	ND		4000	3960
Acrylonitrile	ND		20000	3620
tert-Butyl alcohol (TBA)	ND		2000	1380
trans-1,2-Dichloroethene	ND		1000	460
Methyl tert-butyl ether (MTBE)	ND		1000	540
1,1-Dichloroethane	1120		1000	520
cis-1,2-Dichloroethene	ND		1000	520
Chloroform	20500		1000	520
1,1,1-Trichloroethane	ND		1000	540
Carbon tetrachloride	ND		1000	540
1,2-Dichloroethane (EDC)	185000		1000	740
Benzene	ND		1000	580
Trichloroethene	ND		1000	460
1,2-Dichloropropane	ND		1000	520
Bromodichloromethane	ND		1000	460
2-Chloroethyl vinyl ether	ND		1000	900
cis-1,3-Dichloropropene	ND		1000	480
Toluene	ND		1000	340
trans-1,3-Dichloropropene	ND		1000	640
1,1,2-Trichloroethane	2140		1000	560
Tetrachloroethene	ND		1000	440
Dibromochloromethane	ND		1000	820
Chlorobenzene	ND		1000	540
Ethylbenzene	ND		1000	520
Total Xylenes	ND		2000	1320
Bromoform	ND		1000	900
1,1,2,2-Tetrachloroethane	ND		1000	860
1,3-Dichlorobenzene	ND		1000	980
1,4-Dichlorobenzene	ND		1000	980
1,2-Dichlorobenzene	ND		1000	920

Total Target Compounds (37): 209000

INTEGRATED ANALYTICAL LABORATORIES

VOLATILE ORGANICS

Lab ID: 09359-003
 Client ID: M/B
 Date Received: 09/14/2012
 Date Analyzed: 09/17/2012
 Data file: E5448.D

GC/MS Column: DB-624
 Sample wt/vol: 0.01mL
 Matrix-Units: Aqueous-µg/L (ppb)
 Dilution Factor: 500
 % Moisture: 100

Compound	Concentration	Q	RL	MDL
Chloromethane	ND		250	245
Vinyl chloride	ND		250	160
Bromomethane	ND		250	245
Chloroethane	ND		250	200
Trichlorofluoromethane	ND		250	150
Acrolein	ND		5000	1260
1,1-Dichloroethene	ND		250	140
Methylene chloride	ND		1000	990
Acrylonitrile	ND		5000	905
tert-Butyl alcohol (TBA)	ND		500	345
trans-1,2-Dichloroethene	ND		250	115
Methyl tert-butyl ether (MTBE)	ND		250	135
1,1-Dichloroethane	ND		250	130
cis-1,2-Dichloroethene	ND		250	130
Chloroform	3770		250	130
1,1,1-Trichloroethane	ND		250	135
Carbon tetrachloride	ND		250	135
1,2-Dichloroethane (EDC)	30600		250	185
Benzene	ND		250	145
Trichloroethene	ND		250	115
1,2-Dichloropropane	ND		250	130
Bromodichloromethane	ND		250	115
2-Chloroethyl vinyl ether	ND		250	225
cis-1,3-Dichloropropene	ND		250	120
Toluene	ND		250	85.0
trans-1,3-Dichloropropene	ND		250	160
1,1,2-Trichloroethane	744		250	140
Tetrachloroethene	ND		250	110
Dibromochloromethane	ND		250	205
Chlorobenzene	ND		250	135
Ethylbenzene	ND		250	130
Total Xylenes	ND		500	330
Bromoform	ND		250	225
1,1,2,2-Tetrachloroethane	ND		250	215
1,3-Dichlorobenzene	ND		250	245
1,4-Dichlorobenzene	ND		250	245
1,2-Dichlorobenzene	ND		250	230

Total Target Compounds (37): 35100

INTEGRATED ANALYTICAL LABORATORIES

VOLATILE ORGANICS

Lab ID: 09359-004

Client ID: M/C

Date Received: 09/14/2012

Date Analyzed: 09/18/2012

Data file: E5465.D

GC/MS Column: DB-624

Sample wt/vol: 0.05mL

Matrix-Units: Aqueous-µg/L (ppb)

Dilution Factor: 100

% Moisture: 100

Compound	Concentration	Q	RL	MDL
Chloromethane	ND		50.0	49.0
Vinyl chloride	ND		50.0	32.0
Bromomethane	ND		50.0	49.0
Chloroethane	ND		50.0	40.0
Trichlorofluoromethane	ND		50.0	30.0
Acrolein	ND		1000	251
1,1-Dichloroethene	ND		50.0	28.0
Methylene chloride	ND		200	198
Acrylonitrile	ND		1000	181
tert-Butyl alcohol (TBA)	ND		100	69.0
trans-1,2-Dichloroethene	ND		50.0	23.0
Methyl tert-butyl ether (MTBE)	ND		50.0	27.0
1,1-Dichloroethane	ND		50.0	26.0
cis-1,2-Dichloroethene	ND		50.0	26.0
Chloroform	2070		50.0	26.0
1,1,1-Trichloroethane	ND		50.0	27.0
Carbon tetrachloride	ND		50.0	27.0
1,2-Dichloroethane (EDC)	8190		50.0	37.0
Benzene	ND		50.0	29.0
Trichloroethene	ND		50.0	23.0
1,2-Dichloropropane	ND		50.0	26.0
Bromodichloromethane	ND		50.0	23.0
2-Chloroethyl vinyl ether	ND		50.0	45.0
cis-1,3-Dichloropropene	ND		50.0	24.0
Toluene	ND		50.0	17.0
trans-1,3-Dichloropropene	ND		50.0	32.0
1,1,2-Trichloroethane	416		50.0	28.0
Tetrachloroethene	ND		50.0	22.0
Dibromochloromethane	ND		50.0	41.0
Chlorobenzene	ND		50.0	27.0
Ethylbenzene	ND		50.0	26.0
Total Xylenes	ND		100	66.0
Bromoform	ND		50.0	45.0
1,1,2,2-Tetrachloroethane	ND		50.0	43.0
1,3-Dichlorobenzene	ND		50.0	49.0
1,4-Dichlorobenzene	ND		50.0	49.0
1,2-Dichlorobenzene	ND		50.0	46.0

Total Target Compounds (37):

10700

INTEGRATED ANALYTICAL LABORATORIES

VOLATILE ORGANICS

Lab ID: 09359-005

Client ID: M/CONTROL

Date Received: 09/14/2012

Date Analyzed: 09/25/2012

Data file: L3726.D

GC/MS Column: DB-624

Sample wt/vol: 0.01g

Matrix-Units: Soil-mg/Kg (ppm)

Dilution Factor: 500

% Moisture: 21.2

Compound	Concentration	Q	RL	MDL
Chloromethane	ND		0.635	0.146
Vinyl chloride	ND		0.635	0.419
Bromomethane	ND		0.635	0.349
Chloroethane	ND		0.635	0.266
Trichlorofluoromethane	ND		0.635	0.298
Acrolein	ND		12.7	1.51
1,1-Dichloroethene	ND		0.635	0.527
Methylene chloride	ND		1.27	1.26
Acrylonitrile	ND		12.7	0.996
tert-Butyl alcohol (TBA)	ND		1.27	0.463
trans-1,2-Dichloroethene	ND		0.635	0.324
Methyl tert-butyl ether (MTBE)	ND		0.635	0.178
1,1-Dichloroethane	ND		0.635	0.260
cis-1,2-Dichloroethene	ND		0.635	0.235
Chloroform	2.54		0.635	0.235
1,1,1-Trichloroethane	ND		0.635	0.298
Carbon tetrachloride	ND		0.635	0.451
1,2-Dichloroethane (EDC)	64.1		0.635	0.152
Benzene	ND		0.635	0.152
Trichloroethene	ND		0.635	0.305
1,2-Dichloropropane	ND		0.635	0.235
Bromodichloromethane	ND		0.635	0.197
2-Chloroethyl vinyl ether	ND		0.635	0.222
cis-1,3-Dichloropropene	ND		0.635	0.165
Toluene	ND		0.635	0.146
trans-1,3-Dichloropropene	ND		0.635	0.140
1,1,2-Trichloroethane	0.428	J	0.635	0.171
Tetrachloroethene	ND		0.635	0.317
Dibromochloromethane	ND		0.635	0.197
Chlorobenzene	ND		0.635	0.209
Ethylbenzene	ND		0.635	0.228
Total Xylenes	ND		1.27	0.438
Bromoform	ND		0.635	0.146
1,1,2,2-Tetrachloroethane	ND		0.635	0.152
1,3-Dichlorobenzene	ND		0.635	0.209
1,4-Dichlorobenzene	ND		0.635	0.178
1,2-Dichlorobenzene	ND		0.635	0.209

Total Target Compounds (37): 67.1 J

INTEGRATED ANALYTICAL LABORATORIES

VOLATILE ORGANICS

Lab ID: 09359-006

Client ID: M/A

Date Received: 09/14/2012

Date Analyzed: 09/25/2012

Data file: L3724.D

GC/MS Column: DB-624

Sample wt/vol: 0.05g

Matrix-Units: Soil-mg/Kg (ppm)

Dilution Factor: 100

% Moisture: 19.3

Compound	Concentration	Q	RL	MDL
Chloromethane	ND		0.124	0.029
Vinyl chloride	ND		0.124	0.082
Bromomethane	ND		0.124	0.068
Chloroethane	ND		0.124	0.052
Trichlorofluoromethane	ND		0.124	0.058
Acrolein	ND		2.48	0.295
1,1-Dichloroethene	ND		0.124	0.103
Methylene chloride	ND		0.248	0.245
Acrylonitrile	ND		2.48	0.195
tert-Butyl alcohol (TBA)	ND		0.248	0.090
trans-1,2-Dichloroethene	ND		0.124	0.063
Methyl tert-butyl ether (MTBE)	ND		0.124	0.035
1,1-Dichloroethane	ND		0.124	0.051
cis-1,2-Dichloroethene	ND		0.124	0.046
Chloroform	0.779		0.124	0.046
1,1,1-Trichloroethane	ND		0.124	0.058
Carbon tetrachloride	ND		0.124	0.088
1,2-Dichloroethane (EDC)	16.7		0.124	0.030
Benzene	ND		0.124	0.030
Trichloroethene	ND		0.124	0.060
1,2-Dichloropropane	ND		0.124	0.046
Bromodichloromethane	ND		0.124	0.038
2-Chloroethyl vinyl ether	ND		0.124	0.043
cis-1,3-Dichloropropene	ND		0.124	0.032
Toluene	ND		0.124	0.029
trans-1,3-Dichloropropene	ND		0.124	0.027
1,1,2-Trichloroethane	0.184		0.124	0.034
Tetrachloroethene	ND		0.124	0.062
Dibromochloromethane	ND		0.124	0.038
Chlorobenzene	ND		0.124	0.041
Ethylbenzene	ND		0.124	0.045
Total Xylenes	ND		0.248	0.086
Bromoform	ND		0.124	0.029
1,1,2,2-Tetrachloroethane	ND		0.124	0.030
1,3-Dichlorobenzene	ND		0.124	0.041
1,4-Dichlorobenzene	ND		0.124	0.035
1,2-Dichlorobenzene	ND		0.124	0.041

Total Target Compounds (37): 17.7

INTEGRATED ANALYTICAL LABORATORIES

VOLATILE ORGANICS

Lab ID: 09359-007

Client ID: M/B

Date Received: 09/14/2012

Date Analyzed: 09/26/2012

Data file: F9206.D

GC/MS Column: DB-624

Sample wt/vol: 5g

Matrix-Units: Soil-mg/Kg (ppm)

Dilution Factor: 1

% Moisture: 17.5

Compound	Concentration	Q	RL	MDL
Chloromethane	ND		0.00121	0.000496
Vinyl chloride	ND		0.00121	0.000581
Bromomethane	ND		0.00121	0.000424
Chloroethane	ND		0.00121	0.000545
Trichlorofluoromethane	ND		0.00121	0.000496
Acrolein	ND		0.024	0.00173
1,1-Dichloroethene	ND		0.00121	0.000605
Methylene chloride	ND		0.00242	0.0024
Acrylonitrile	ND		0.024	0.00227
tert-Butyl alcohol (TBA)	ND		0.00484	0.0011
trans-1,2-Dichloroethene	ND		0.00121	0.00052
Methyl tert-butyl ether (MTBE)	ND		0.00121	0.000278
1,1-Dichloroethane	ND		0.00121	0.000327
cis-1,2-Dichloroethene	ND		0.00121	0.000375
Chloroform	ND		0.00121	0.000351
1,1,1-Trichloroethane	ND		0.00121	0.000399
Carbon tetrachloride	ND		0.00121	0.000496
1,2-Dichloroethane (EDC)	0.011		0.00121	0.000254
Benzene	ND		0.00121	0.00029
Trichloroethene	ND		0.00121	0.000387
1,2-Dichloropropane	ND		0.00121	0.000266
Bromodichloromethane	ND		0.00121	0.000387
2-Chloroethyl vinyl ether	ND		0.00121	0.000278
cis-1,3-Dichloropropene	ND		0.00121	0.000315
Toluene	ND		0.00121	0.000303
trans-1,3-Dichloropropene	ND		0.00121	0.000315
1,1,2-Trichloroethane	0.000502	J	0.00121	0.000242
Tetrachloroethene	ND		0.00121	0.000315
Dibromochloromethane	ND		0.00121	0.000266
Chlorobenzene	ND		0.00121	0.000266
Ethylbenzene	ND		0.00121	0.000375
Total Xylenes	ND		0.00242	0.00128
Bromoform	ND		0.00121	0.000387
1,1,2,2-Tetrachloroethane	ND		0.00121	0.000278
1,3-Dichlorobenzene	ND		0.00121	0.000375
1,4-Dichlorobenzene	ND		0.00121	0.000375
1,2-Dichlorobenzene	ND		0.00121	0.000436

Total Target Compounds (37): 0.012

J

E12-09359

0000

INTEGRATED ANALYTICAL LABORATORIES

VOLATILE ORGANICS

Lab ID: 09359-008

Client ID: M/C

Date Received: 09/14/2012

Date Analyzed: 09/26/2012

Data file: F9207.D

GC/MS Column: DB-624

Sample wt/vol: 5g

Matrix-Units: Soil-mg/Kg (ppm)

Dilution Factor: 1

% Moisture: 20.1

Compound	Concentration	Q	RL	MDL
Chloromethane	ND		0.00125	0.000513
Vinyl chloride	ND		0.00125	0.0006
Bromomethane	ND		0.00125	0.000438
Chloroethane	ND		0.00125	0.000563
Trichlorofluoromethane	ND		0.00125	0.000513
Acrolein	ND		0.025	0.00179
1,1-Dichloroethene	ND		0.00125	0.000625
Methylene chloride	ND		0.0025	0.00248
Acrylonitrile	ND		0.025	0.00235
tert-Butyl alcohol (TBA)	ND		0.005	0.00114
trans-1,2-Dichloroethene	ND		0.00125	0.000538
Methyl tert-butyl ether (MTBE)	ND		0.00125	0.000288
1,1-Dichloroethane	ND		0.00125	0.000338
cis-1,2-Dichloroethene	ND		0.00125	0.000388
Chloroform	ND		0.00125	0.000363
1,1,1-Trichloroethane	ND		0.00125	0.000413
Carbon tetrachloride	ND		0.00125	0.000513
1,2-Dichloroethane (EDC)	0.00632		0.00125	0.000263
Benzene	ND		0.00125	0.0003
Trichloroethene	ND		0.00125	0.0004
1,2-Dichloropropane	ND		0.00125	0.000275
Bromodichloromethane	ND		0.00125	0.0004
2-Chloroethyl vinyl ether	ND		0.00125	0.000288
cis-1,3-Dichloropropene	ND		0.00125	0.000325
Toluene	ND		0.00125	0.000313
trans-1,3-Dichloropropene	ND		0.00125	0.000325
1,1,2-Trichloroethane	0.000455	J	0.00125	0.00025
Tetrachloroethene	ND		0.00125	0.000325
Dibromochloromethane	ND		0.00125	0.000275
Chlorobenzene	ND		0.00125	0.000275
Ethylbenzene	ND		0.00125	0.000388
Total Xylenes	ND		0.0025	0.00133
Bromoform	ND		0.00125	0.0004
1,1,2,2-Tetrachloroethane	ND		0.00125	0.000288
1,3-Dichlorobenzene	ND		0.00125	0.000388
1,4-Dichlorobenzene	ND		0.00125	0.000388
1,2-Dichlorobenzene	ND		0.00125	0.00045

Total Target Compounds (37): 0.00678

J

E12-09359

0010

INTEGRATED ANALYTICAL LABORATORIES, LLC.

Ferrous (II) Iron

Client/Project: ISOTEC/PB&W/FORMOSA PLASTICS - 901132

Date Received: 09/14/12 17:30

Lab ID	Client ID	Result	Q	DF	Matrix-Unit	MDL	RL	% Solid	Date Analyzed
09359-001	M/CONTROL	ND		1	Aqueous-ug/L	40.0	200	0	09/14/12 17:35
09359-002	M/A	ND		1	Aqueous-ug/L	40.0	200	0	09/14/12 17:35
09359-003	M/B	ND		1	Aqueous-ug/L	40.0	200	0	09/14/12 17:35
09359-004	M/C	ND		1	Aqueous-ug/L	40.0	200	0	09/14/12 17:35



Integrated Analytical Labs
273 Franklin Road
Randolph, NJ 07869

Contact Us: 973-361-4252
Fax: 973-989-5288
Web: www.lalonline.com

CUSTOMER INFO		REPORTING INFO	
Company: ISOTEC - NJ	REPORT TO:	Turnaround Time (starts the following day if samples rec'd at lab > 5PM) *Lab notification is required for RUSH TAT prior to sample arrival. RUSH TAT IS NOT GUARANTEED WITHOUT LAB APPROVAL. **RUSH SURCHARGES WILL APPLY IF ABLE TO ACCOMMODATE PHC - MUST CHOOSE NJ EPH DRO (5 day TAT) NJ EPH Fractionated (5 day TAT) NJ EPH - C40 (5 day TAT) DRO-8015 (3-5 day TAT) QAM025 (5 day TAT) <u>Verbal/Fax: Std 2 wk unless otherwise specified</u> 24 hr** 48 hr** 72 hr** 96 hr** 1 wk** Other** (specify): Hard Copy: Std 3 week * Other - call for price	
Address:	Address:		
Telephone #:	Attn:		
Fax #:	FAX #		
Project Manager: Prasad Kakarala	INVOICE TO:		
EMAIL Address:	Address:	Rush TAT Charge ** 24 hr - 100%... 48 hr - 75%... 72 hr - 50%... 96 hr - 35%... 5 day - 25%... 6-9 day 10% Report Format <u>Results Only</u> Reduced Regulatory - 15% Surcharge applies Other (describe) EDDs NJ SRP format NYSDEC lab approved custom EDD NO EDD/CD REQ'D	
Sampler: Yan Chin			
Project Name: PB&W/Formosa Plastics			
Project Location (State): TX	Attn:		
Bottle Order #:	PO # 4258		
Quote #: 901132	Sample Matrix DW - Drinking Water AQ - Aqueous WYW - Waste Water OI - Oil LIQ - Liquid (Specify) OT - Other (Specify) S - Soil SL - Sludge SOL - Solid W - Wipe		

SAMPLE INFORMATION

Client ID	Depth (ft only)	Sampling		Matrix	# container	IAL #	ANALYTICAL PARAMETERS												# BOTTLES & PRESERVATIVES							
		Date	Time				VOCs	Ferrous	iron										HCL	HNO3	MeOH	NaOH	H2SO4	Other	Nose	Encore
M/C Control		9/14/12		AQ	1+1	1	X	X											1						1	
M/A						2		X											1						1	
M/B						3		X											1						1	
M/C						4		X																	1	
M/C Control				S	1	5																			1	
M/A						6																			1	
M/B						7																			1	
M/C						8																			1	

Known Hazard: Yes or No Describe: Conc. Expected: Low Med High MDL Req: GWQS (11/05) - SRS - SRS/IGW - SRS Residential - OTHER (SEE COMMENTS)

Please print legibly and fill out completely. Samples cannot be processed and the turnaround time will not start until any ambiguities have been resolved.

Carrier (check one)		IAL Courier		Client Courier		FedEx/UPS	
Signature/Company	Date	Time	Signature/Company	Date	Time		
Relinquished by: <i>[Signature]</i>	9/14/12	1pm	Received by: <i>[Signature]</i>	9/14/12	1500		
Relinquished by: <i>[Signature]</i>	9/14/12	1730	Received by: <i>[Signature]</i>	9/14/12	1730		
Relinquished by:			Received by:				
Relinquished by:			Received by:				
Relinquished by:			Received by:				

LAB COPIES - WHITE & YELLOW; CLIENT COPY - PINK

132012 REV COC

Control
Comments: Use lowest MDLs possible.
MDLs for "1" should NOT be lower than MDLs for other samples.

Lab Case #

09359

PAGE: 1 of 1

01/2012 rev

PROJECT INFORMATION



Case No. **E12-09359** Project **PB&W/TORMOSA PLASTICS - 901132**

Customer **Isotec**

P.O. # **4258**

Contact **Prasad Kakarla**

Received **9/14/2012 17:30**

EMail **pkakarla@insituoxidation.com;** ☒ EMail EDDs

Verbal Due **10/1/2012**

Phone **ychin@insituoxidation.com**
(609) 275-8500 Fax **1(609) 275-9608**

Report Due **10/8/2012**

Report To

Bill To

11 Princess Road

11 Princess Road

Suite A

Suite A

Lawrenceville, NJ 08648

Lawrenceville, NJ 08648

Attn: Prasad Kakarla

Attn: Prasad Kakarla

Report Format **Result Only**

Additional Info ☐ State Form ☐ Field Sampling ☐ Conditional VOA

Lab ID	Client Sample ID	Depth Top / Bottom	Sampling Time	Matrix	Unit	# of Containers
09359-001	M/CONTROL	n/a	9/14/2012	Aqueous	ug/L	2
09359-002	M/A	n/a	9/14/2012	Aqueous	ug/L	2
09359-003	M/B	n/a	9/14/2012	Aqueous	ug/L	2
09359-004	M/C	n/a	9/14/2012	Aqueous	ug/L	2
09359-005	M/CONTROL	n/a	9/14/2012	Soil	mg/Kg	1
09359-006	M/A	n/a	9/14/2012	Soil	mg/Kg	1
09359-007	M/B	n/a	9/14/2012	Soil	mg/Kg	1
09359-008	M/C	n/a	9/14/2012	Soil	mg/Kg	1

Sample #	Tests	Status	QA Method
001	PP VO + Cis 1,2-DCE + MTBE .TBA	In Process	624
"	Ferrous (II) Iron	Run	SM20 3500 Fe B
002	PP VO + Cis 1,2-DCE + MTBE .TBA	In Process	624
"	Ferrous (II) Iron	Run	SM20 3500 Fe B
003	PP VO + Cis 1,2-DCE + MTBE .TBA	In Process	624
"	Ferrous (II) Iron	Run	SM20 3500 Fe B
004	PP VO + Cis 1,2-DCE + MTBE .TBA	In Process	624
"	Ferrous (II) Iron	Run	SM20 3500 Fe B
005	PP VO + Cis 1,2-DCE + MTBE .TBA	Run	8260B
006	PP VO + Cis 1,2-DCE + MTBE .TBA	Run	8260B
007	PP VO + Cis 1,2-DCE + MTBE .TBA	Run	8260B
008	PP VO + Cis 1,2-DCE + MTBE .TBA	Run	8260B

09/17/2012 10:22 by Ellen - NOTE 1

USE LOWEST POSSIBLE MDLs. MDLs FOR CONTROL SAMPLES SHOULD NOT BE LOWER THAN MDLs FOR OTHER SAMPLES.

PROJECT INFORMATION



Case No. **E12-09359**

Project **PB&W/FORMOSA PLASTICS - 901132**

09/17/2012 16:37 by Mark - NOTE 2

SAMPLES #005 - 008 HAVE SOIL LAYER & WATER LAYER. PER YAN CHEN, ANALYZE SOIL LAYER ONLY

INTEGRATED ANALYTICAL LABORATORIES, LLC

SAMPLE RECEIPT VERIFICATION

CASE NO: E 12

09359

CLIENT:

PROTEC

COOLER TEMPERATURE: 2° - 6°C: ☒

(See Chain of Custody)

Comments

COC: COMPLETE / INCOMPLETE

KEY

☒ = YES/NA
☒ = NO

☒ Bottles Intact
☒ no-Missing Bottles
☒ no-Extra Bottles

☒ Sufficient Sample Volume
☒ no-headspace/bubbles in VO's
☒ Labels intact/correct
☒ pH Check (exclude VO's)¹
☒ Correct bottles/preservative
☒ Sufficient Holding/Prep Time¹

☐ Sample to be Subcontracted

☒ Chain of Custody is Clear

¹ All samples with "Analyze Immediately" holding times will be analyzed by this laboratory past the holding time. This includes but is not limited to the following tests: pH, Temperature, Free Residual Chlorine, Total Residual Chlorine, Dissolved Oxygen, Sulfite.

ADDITIONAL COMMENTS:

SAMPLE(S) VERIFIED BY:

INITIAL

[Signature]

DATE

9/14/12

CORRECTIVE ACTION REQUIRED:

YES

☐

(SEE BELOW)

NO

☐

If COC is **NOT** clear, **STOP** until you get client to authorize/clarify work.

CLIENT NOTIFIED:

YES

☐

Date/ Time:

NO

☐

PROJECT CONTACT:

SUBCONTRACTED LAB:

DATE SHIPPED:

ADDITIONAL COMMENTS:

VERIFIED/TAKEN BY:

INITIAL

[Signature]

DATE

9/17/12

E12-0000002009 0015

Laboratory Custody Chronicle

IAL Case No.

E12-09359

Client Isotec

Project PB&W/FORMOSA PLASTICS - 901132

Received On 9/14/2012@17:30

<u>Department: Volatiles</u>			<u>Prep. Date</u>	<u>Analyst</u>	<u>Analysis Date</u>	<u>Analyst</u>
PP VO + Cis 1,2-DCE + MTBE & TBA	09359-001	Aqueous	n/a	n/a	9/17/12	Barbara
"	-002	"	n/a	n/a	9/17/12	Barbara
"	-003	"	n/a	n/a	9/17/12	Barbara
"	-004	"	n/a	n/a	9/18/12	Barbara
"	-005	Soil	n/a	n/a	9/25/12	Mei
"	-006	"	n/a	n/a	9/25/12	Mei
"	-007	"	n/a	n/a	9/26/12	Xing
"	-008	"	n/a	n/a	9/26/12	Xing

<u>Department: Wet Chemistry</u>			<u>Prep. Date</u>	<u>Analyst</u>	<u>Analysis Date</u>	<u>Analyst</u>
Ferrous (II) Iron	-001	Aqueous	n/a	n/a	9/14/12@17:35	Kris
"	-002	"	n/a	n/a	9/14/12@17:35	Kris
"	-003	"	n/a	n/a	9/14/12@17:35	Kris
"	-004	"	n/a	n/a	9/14/12@17:35	Kris



ANALYTICAL DATA REPORT

Isotec
11 Princess Road
Suite A
Lawrenceville, NJ 08648

Project Name: **PB&W/FORMOSA PLASTICS - 901132**
IAL Case Number: **E12-09628**

These data have been reviewed and accepted by:

Michael H. Lefth, Ph.D.
Laboratory Director

This report shall not be reproduced, except in its entirety, without the written consent of Integrated Analytical Laboratories, LLC. The test results included in this report relate only to the samples analyzed.

273 Franklin Road
Randolph, NJ 07869
Phone: 973 361 4252
Fax: 973 989 5288



IAL is a NELAC New Jersey Certified Lab (14751) and maintains certification in Connecticut (PH-0699), New York (11402), Rhode Island (00126), Pennsylvania (68-00773) and in the Department of Navy IR QA Program

Sample Summary

IAL Case No.

E12-09628

Client Isotec

Project PB&W/FORMOSA PLASTICS - 901132

Received On 9/21/2012@18:45

<u>Lab ID</u>	<u>Client Sample ID</u>	<u>Depth Top/Bottom</u>	<u>Sampling Time</u>	<u>Matrix</u>	<u># of Container</u>
09628-001	S-A/CONTROL AQUEOUS SAMPI	n/a	9/21/2012@13:00	Aqueous	1
09628-002	S-A/A AQUEOUS SAMPLE	n/a	9/21/2012@13:00	Aqueous	1
09628-003	S-A/B AQUEOUS SAMPLE	n/a	9/21/2012@13:00	Aqueous	1
09628-004	S-A/C AQUEOUS SAMPLE	n/a	9/21/2012@13:00	Aqueous	1
09628-005	S-H/CONTROL AQUEOUS SAMPI	n/a	9/21/2012@13:00	Aqueous	1
09628-006	S-H/A AQUEOUS SAMPLE	n/a	9/21/2012@13:00	Aqueous	1
09628-007	S-H/B AQUEOUS SAMPLE	n/a	9/21/2012@13:00	Aqueous	1
09628-008	S-H/C AQUEOUS	n/a	9/21/2012@13:00	Aqueous	1
09628-009	S-A/CONTROL SOIL SAMPLE	n/a	9/21/2012@13:00	Soil	1
09628-010	S-A/A SOIL SAMPLE	n/a	9/21/2012@13:00	Soil	1
09628-011	S-A/B SOIL SAMPLE	n/a	9/21/2012@13:00	Soil	1
09628-012	S-A/C SOIL SAMPLE	n/a	9/21/2012@13:00	Soil	1
09628-013	S-H/CONTROL SOIL SAMPLE	n/a	9/21/2012@13:00	Soil	1
09628-014	S-H/A SOIL SAMPLE	n/a	9/21/2012@13:00	Soil	1
09628-015	S-H/B SOIL SAMPLE	n/a	9/21/2012@13:00	Soil	1
09628-016	S-H/C SOIL SAMPLE	n/a	9/21/2012@13:00	Soil	1

INTEGRATED ANALYTICAL LABORATORIES, LLC.

TABLE OF CONTENTS

	<u>Page</u>
Qualifiers	1
Results Summary Report	2
Analytical Results	5
Volatiles	6
Sample Tracking	22
Chains of Custody	
Project Information	
Sample Receipt Verification	
Laboratory Chronicle	
Last Page of the Report	27

This report was finalized on October 12, 2012

INTEGRATED ANALYTICAL LABORATORIES, LLC.

DEFINITIONS / QUALIFIERS

DATA QUALIFIERS

- B Indicates the analyte was found in the associated method blank as well as in the sample. It indicates probable laboratory contamination.
- C Indicates analyte is a common laboratory contaminant.
- D Indicated analyte was reported from diluted analysis.
- E Identifies a compound concentration that exceeds the upper level of the calibration range of the instrument for that specific analysis.
- J Indicates an estimated value. This flag is used when the concentration in the sample is below the RL but above the MDL.

REPORTING DEFINITIONS

- RL Reporting Limit. The RL is determined by the lowest concentration in the calibration curve. For most Wet Chemistry methods, the RL is defined by using the PQL.
- MDL Method Detection Limit as determined according to 40CFR Part 136 Appendix B.
- PQL Practical Quantitation Limit. Usually defined as a value 3-5 times the MDL.
- ND Indicates analyte was analyzed for but not detected above the MDL.
- DF Dilution Factor
- LCS Laboratory Control Sample
- LCSD Laboratory Control Sample Duplicate
- MS Matrix Spike
- MSD Matrix Spike Duplicate
- DUP Duplicate